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AN/TPS-61() HOSTILE WEAPON LOCATION TEST

by

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes the modification of the AN/TPS-61 radar for hostile weapon location and the subsequent testing at Dahlgren, Virginia and Fort Sill, Oklahoma. The objective of the program was to determine hostile weapon location effectiveness, evaluation of mission data, and recommend system improvements. The radar system, test environment, test results, operational considerations, and recommended improvements are described. Performance against all three classes of field artillery (mortars, howitzers,		
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and guns) was evaluated. In addition, the TPS-61() was evaluated as an Air Surveillance Radar (ASR).

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FOREWORD

The format of this final report is organized to adapt to the interest level of the reader. Each topic has been limited to two pages. The left hand page contains the essence of each subject in pictorial, graphical, or tabular format. In many instances, this material is self-explanatory. On the right hand page, the details are described in narrative form. This page should be consulted for the background, details, and additional comments. Those items which are not readily explained in two pages are contained in the annexes. A glossary of terms is included for the convenience of the reader.

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AN/TPS-61() TEST OBJECTIVES

- Modify Basic TPS-61 for Hostile Weapon Location
- Familiarization with Projectile Detection at Dahlgren, Va.
- Determination of Weapon Location Capability at Fort Sill, Okla.
 - 1. Weapon Location in Clutter
 - 2. Determination of Weapon Class
 - 3. Weapon Location Using Resection Technique
 - 4. Observation of Air Burst Signature
 - 5. Effects of Radar Masking
 - 6. Effects of Single Piece vs Battery Firings
 - 7. Long Range Weapon Location.
- Mission Data Evaluation
- System Improvement Recommendations.

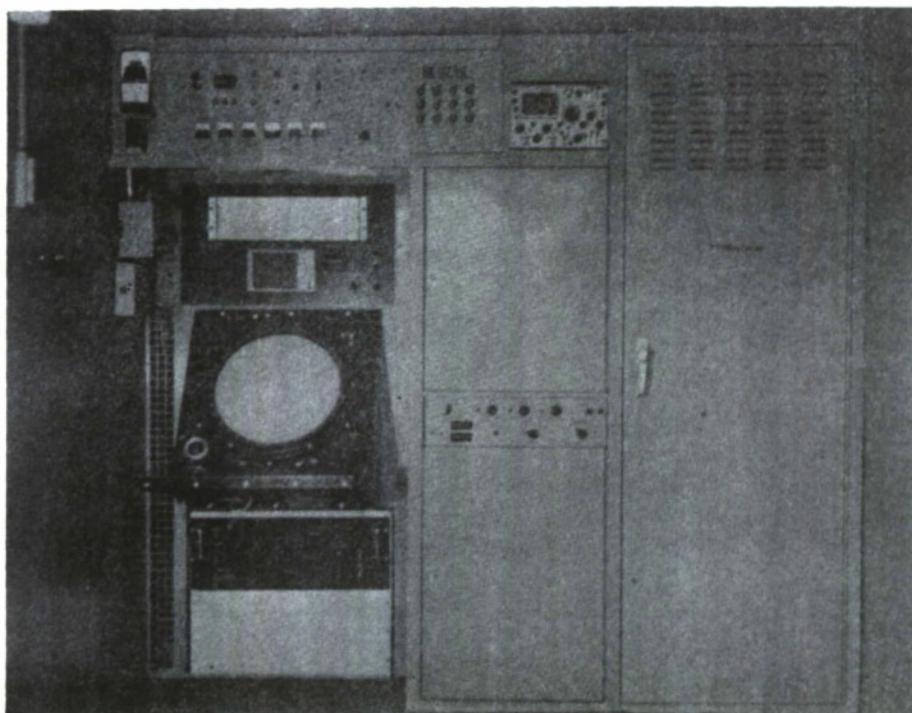
AN/TPS-61 DEMONSTRATED ACHIEVEMENT
(FORT SILL, OKLA. TESTS)

- Weapon Location at Ranges in excess of 25 km
- Weapon Located for 58 out of 73 Mission Sequences (80 percent)

<u>Mission Category</u>	<u>Number of Missions</u>	<u>Location Accuracy C.E.P. (Meters)</u>
All Missions	58	400
All Unknowns	29	360
Unknowns (No Mortars)	19	280
All Missions (After 6 Feb.)	18	220
• First or Second Round Cueing Capability on 75 percent of unknown mission (1 degree Azimuth Cueing Capability)		
• One Radar Failure in 8 Weeks of Field Tests		
• Tracked UH-IH Helicopter Out to 13 nmi at 25 ft Altitude (USAASO Test)		
• Supported Missions in Foul Weather (Ice Storms, Rain, Snow, 50 Knot Peak Winds).		



A. In Operation at Fort Sill, Okla.



B. Interior View*

* 2/3 of S-280 Shelter Available for Operations Use

73-0640 PB 1

Figure 1. TPS-61

FORT SILL TEST - LESSONS LEARNED

- Point clutter (towers, junked cars, mountains, etc) can capture pulse compression mode
- Projectiles observed behind optical mask
- Wide variations in projectile radar cross sections
- Raw radar data gave best estimate (computer not required)
- Point clutter attracts mortar engagements
- Experience improves location estimates
- Battery fire easier to locate than single weapon
- Five rounds sufficient for quoted accuracies
- Higher data rate and subclutter visibility (SCV) would be valuable.

AN/TPS-61() SYSTEM DESIGN

- Frequency L-Band
- Range 30 km (-20 DBSM Target)
- Coverage (2-D Radar) 360° (Azimuth)
> 20 KFT (Altitude)
- Resolution 300 Meters (Range)
2.7° (Azimuth)
- SCV 50 dB
- Data Rate 4 Seconds per Scan
25 Hits/Scan
- Minimum Range ≈ 1.5 nmi
- Radial Velocity Coverage > 20 m/s
- Display Resolution 0.1 nmi (185 m) - Range
0.1 degree (1.8 mils) - Azimuth

AN/TPS-61() HARDWARE DESCRIPTION

- Antenna
 - Integral Radar/IFF Feed
 - Doubly Curved Reflector (CSC²)
18 feet wide.
- Transmitter
 - Final Stage - Cross Field Amplifier
(100 kW peak, 2.5 kW average)
 - Totem Pole Driver - 5 Stage
(5 kW peak, 125 W average)
 - Pulsewidth - 26 μ sec Phase Coded.
- Receiver
 - Transistorized RF Amplifier
(NF = 4.5 dB)
 - Digital MTI (4 Pulse Canceller,
10 Bits/Word)
 - Digital Pulse Compression
(2 μ sec Decoded)
 - Digital Video Integration (15/16 Feedback).
- Display
 - 16-inch PPI
 - B-Scope Storage Tube.
- Shelter
 - S-280 Shelter (2/3 Empty Space)
 - Antenna Stows in Shelter During Transit
 - Weight = 3,700 pounds (total system
weight including shelter, radar and
antenna).
- Power Requirements
 - 20 kW, 3 ϕ , 400 Hz.

MODIFICATIONS MADE TO BASIC AN/TPS-61

- New Equipment
 - B-Scope Storage Tube
 - AN/UPA-62 PPI Display
 - Video Mapper
 - Programmable Computer.
- Mechanical Changes
 - 15 rpm Antenna Scan (4 second data rate)
 - Antenna Searchlight Mode
 - Heat Exchanger.
- Mechanical Repackaging
 - Transmitter (Low Voltage Power Supply)
 - Receiver (RF Front End and Frequency Generator)
 - Display Area.
- Design Changes - Turn off Pulser Transformer.

AN/TPS-61 MODIFICATIONS FOR WEAPON LOCATION

The AN/TPS-61 had been previously employed to provide medium-range low-altitude air surveillance of aircraft. The two basic parameters of high average power and clutter cancellation are the foundation for weapon location and air surveillance. The equipment modification consisted of new subsystems for weapon location and mechanical repackaging for improved operation (through interference reduction, more work space, and greater reliability).

A new display was installed for the weapon location task. This included a 16-inch PPI with decimal readout of range and azimuth. A 2:1 expansion of the sweep range permitted display of ranges consistent with detection of projectiles. A storage tube B-scope was provided, to accurately locate the origin of the hostile weapon trajectory. A video mapper was installed, to mark prominent features on the PPI. A programmable desk top computer allowed correction of raw data for earth's curvature, weapon-radar height differential, terrain masking, and nonsynchronous radar scan-weapon firing operation.

Previously, the radar had been operated at a 6 rpm scan rate. For weapon location purposes a higher scan rate of 15 rpm was provided. The radar was modified to provide a manual control of the antenna in azimuth (searchlight mode), and sector blanking of the transmitter as a function of azimuth was installed, for safety purposes. At Dahlgren, Va., the radar was operated near residential areas which were outside the regions of interest; consequently, the transmitter was turned off when the radar was pointing towards these areas. The heat exchanger was reconfigured to permit stowage in the shelter. Mechanical repackaging of the transmitter and receiver was undertaken to reduce internal interference between subsystems. For weapon location applications the radar operated continuously in the high average power mode; consequently, the turn-off pulser transformer was redesigned for a higher current rating.

CALIBRATION AND MAINTENANCE PROCEDURES

- Antenna Azimuth Reference Calibration (30 Minutes):

<u>Purpose</u>	Align PPI azimuth readings with Grid North as reference.
<u>Procedure</u>	<ol style="list-style-type: none">1. Stabilize Radar System (Level Check)2. Locate Prominent Point Clutter (Tower)3. Attenuation of Receiver4. Manual Alignment of Synchro5. Verify Specific Point Clutter with Range Readout.

- Daily Preventive Maintenance (20 Minutes):

<u>Purpose</u>	Determine system performance prior to mission.
<u>Procedure</u>	<ol style="list-style-type: none">1. Receiver Alignment and MDS Checks2. Transmitter Waveform Checks3. Inspect water level in Heat Exchanger4. Verify Azimuth Reference5. Inspect Microwave Components for deposits6. Monitor Final Stage Output Current.

ANTENNA ALIGNMENT AND DAILY PREVENTIVE MAINTENANCE

The antenna synchro alignment is presently an electrical procedure dependent upon locating prominent point clutter such as water towers or TV towers. This procedure is accomplished using the searchlighting mode, attenuating the receiver front end until the designated point clutter is reduced to an MDS point on the PPI. The B-scope window is placed in the area, providing a precise readout of the video. The clutter point is read to the nearest 0.1 degree, and the synchro is aligned to the known azimuth. A substantial reduction in implacement time would be realized by installing an optical boresighting device. The optical/electrical axis would be aligned at the factory. The tactical advantage is also obvious.

Daily maintenance procedures include receiver and transmitter set-up for normal operation. The receiver alignment, MDS, and cancellation are checked out with internally generated L-band test targets which allow the receiver to be totally checked without turning on the transmitter.

The transmitter checkout is a two-stage process. It consists, first, of a low-power Totem Pole Amplifier with associated meters and waveforms test points for monitoring; the second stage consists of high power, CFA, radiation monitoring of the CPA current waveform, and CFA detected RF output. A single operator can set up both receiver and transmitter in about 15 minutes using the front panel meters and test points for go/no-go operation.

Weekly maintenance duties consist of water level and pressure checks of the heat exchange unit, cleaning air conditioning filters, checking azimuth reference, and antenna checkout for mechanical integrity.

The humidity (condensation on the equipment) experienced in the morning was removed by operating the heater/air-conditioning unit.

OPERATIONS AT FORT SILL

- Mobility

- All equipment placed on 5-ton truck
- 30 minute march order time
- One hour implacement time
- Assembled/disassembled 24 times
- Transported weekly to/from test site.

- Logistical Support

- 45 kW, 400 Hz Generator
- 5 kW, 60 Hz Generator
- Survey
- Aiming Circle.

- Reliability

- 196 hours of operation
- 40 days at Fort Sill
- One failure in 9 weeks
- Supported all 17 tests.

- Operational Test Environment

- 50 knot winds
- Ice storm
- Rain and snow
- Mountainous terrain.

OPERATIONS AT FORT SILL, OKLA.

The AN/TPS-61 was operated and maintained by a three-man crew during the 9 weeks of testing at Fort Sill. A 5 ton truck was used to transport the radar; a 2-1/2 ton truck (M35, M36), however, would have been sufficient. Aside from the movement between radar sites, the system was transported weekly to and from the base motor pool.

A 45 kW generator was used to supply prime power for the radar; the system, however, actually draws only 20 kW under a full load. A 60 cycle generator was used for test video recordings and on-site computations, which are not necessary in a tactical situation. First order surveys of three radar sites were provided by Fort Sill; lower order surveys, however, would have been sufficient. The aiming circle was used to obtain azimuth masking angles and azimuth readings to calibration towers.

All missions during the 40-day test period were supported, with only one radar failure. This was an MOS memory failure, repaired by replacement with a spare plug-in module. The AN/TPS-61() operated in some severe weather environments. These included 50 knot peak winds and ice storms during the 105 mm howitzer location test (with site masking), and a snow storm with visibility of 1,000 meters during the 8-inch howitzer location test.

Hours Logged at Fort Sill, Oklahoma

<u>Subsystem</u>	<u>Hours Logged</u>
Receiver (Radar)	196
Totem Pole (Low Power)	114
CFA (High Power)	102

TPS-61 Display

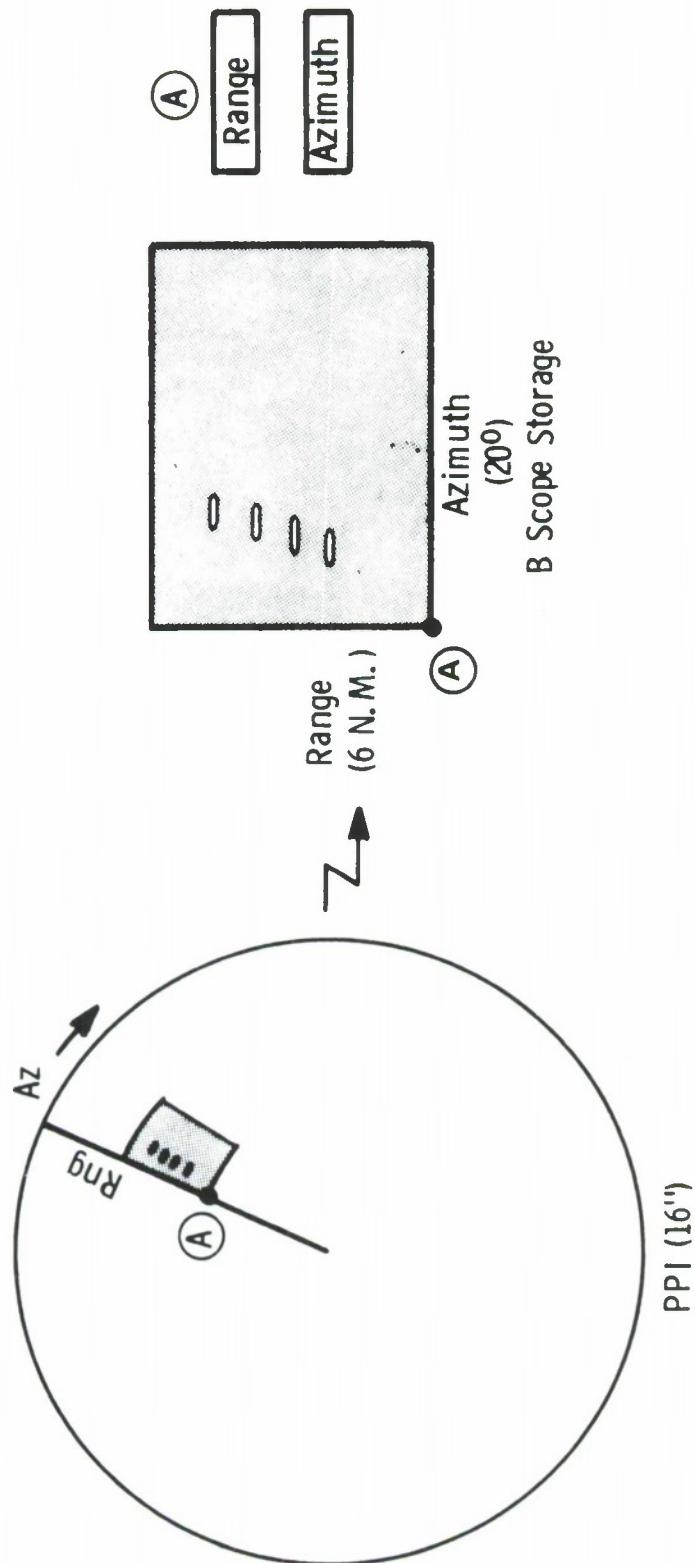


Figure 2. TPS-61 Display

73-0640-VB-2

HOW WEAPON LOCATION IS DETERMINED BY AN/TPS-61() RADAR

The firing of a hostile weapon is first observed on the PPI display as successive scans. The operator places his cursor over the region of interest and ensures that the area to be expanded on the B-scope is adequate to cover the trajectory. The expansion area is clearly marked on the PPI. The dot A on the PPI and B-scope is presented in a decimal display to the nearest 0.1 degree and 0.1 nautical mile. The maximum expanded sector is 6 nmi in range and 20 degrees in azimuth and was employed exclusively during the Fort Sill tests. Two additional scales are available: 1.5 nmi by 5 degrees and 3 nmi by 10 degrees.

The operator then views the B-scope for the furthest scan back on the trajectory for successive rounds. After about five rounds, the furthest scan is marked. This represents the scan nearest the weapon firing. Several rounds should be observed, for maximum accuracy, to ensure that the radar scanned by the weapon as it was firing. There is no need to mark all scans, as the B-scope is a storage tube device, i.e., one with infinite persistence. The final radar estimate of range and azimuth is obtained by adding the decimal-displayed values and the graduated-scale values of the point marked. The B-scope can be erased or frozen, at operator option, by a pushbutton. Actual photos of weapons firing on the B-scope will be presented later.

USE OF COMPUTER FOR WEAPON LOCATION ESTIMATE

- Computer Corrections

- Nonsynchronous Firing and Radar Scan
- Earth's Curvature
- Radar-Weapon Height Differential
- Radar Masking.

- Test Data Indicates Use of Computer Questionable

- 55 percent of Sequences, Computer (without Mask Correction) gave worse answers than raw radar data
- 83 percent of Sequences, Computer (with Mask Correction) gave worse answers than raw radar data.

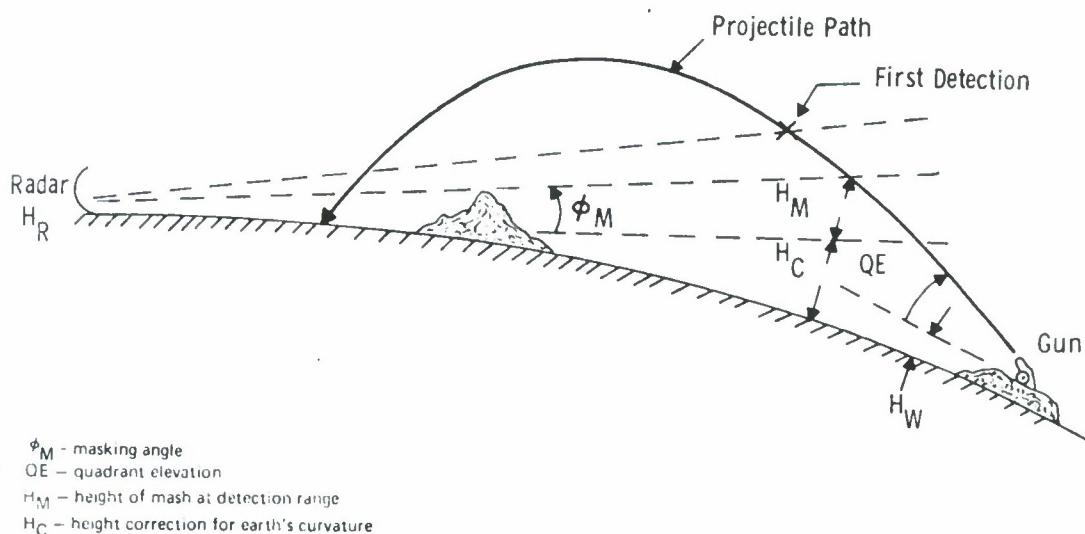


Figure 3. Physical Interpretation of Computer Corrections

COMPUTER CORRECTIONS TO RAW RADAR DATA

A programmable desktop computer was employed at Fort Sill to correct raw radar weapon coordinates. Four basic corrections were implemented. The radar scan and weapon firing are not synchronous operations. A probabilistic correction was made as a function of the number of rounds observed. The more rounds fired, the more likely that the radar scanned by as a weapon fired. Typically, five rounds were sufficient to remove this uncertainty. The earth's curvature and radar-weapon height differential corrections were also computed. These three corrections are described as location correction without masking. For those situations where the weapon is located below the visual terrain profile, an additional correction was performed. From an estimation of QE, described elsewhere, the location of the weapon is extrapolated back to account for the blind portion of the trajectory. Complete details of the procedure are described in Annex III. From the data reduced from the Fort Sill tests, it appears that the computer corrections gave worse location errors than the raw radar data. In the case of data correction, without masking, the average improved estimate was 182 meters and the average poorer estimate was 166 meters. The significant reason for poorer estimates with masking is the electromagnetic diffraction phenomenon and the variation of masking within a radar beamwidth. Many times the projectile was observed "out of the tube" even with an optical mask in the radar path.

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AN/TPS-61() VARIABLE OPERATING MODES

- Transmitter
 - High and Low Power
- PRF
 - High/Low and Fixed/Swept (Any Combination)
- Receiver
 - MTI/Integrator/STC "On/Off" Independently
 - Normal/Test
- Antenna
 - Scan/Searchlight
- Display
 - Range Scale on PPI Continuously Variable
 - Expanded Sector on B-Scope Selectable.

AN/TPS-61() OPERATING MODES

<u>Subsystem</u>	<u>Mode</u>	<u>Usage</u>	<u>Remarks</u>
Transmitter	1) High Power 2) Low Power 3) Low Power	Primary Back-Up Back-Up	26 μ sec Coded Pulse (Long Range Detection) 4 μ sec Uncoded Pulse (36 percent Range Reduction) Final Power Amplifier "Off" (53 to 65 percent Range Reduction)
PRF	1) High Swept 2) Low Swept	Primary Back-Up	No Blind Speeds and Maximum Clutter Rejection Used for very low Radial Velocity Targets in Low clutter areas
	3) High Fixed 4) Low Fixed	Verify Verify	Used to verify suspected 2nd time around targets (momentary usage)
Receive	1) MTI/Integ/STC 2) Normal Video Test 3) R.F. Target Test	Primary	Employed in any Transmit/PRF Mode Used to determine MTI performance Maintenance and troubleshooting applications
Antenna	1) Scan 2) Searchlight	Primary Secondary	15 rpm Standard (field change to 4, 6, or 12 rpm) Antenna controlled by Operator (CW or CCW)
Display	1) 20 nmi PPI 2) 10, 5 nmi PPI 3) 80, 160 nmi PPI	Primary Secondary Air-Surveillance PPI	2:1 continuously variable expansion of each range scale
	4) Centered Origin 5) Off Centered Origin	Primary Secondary	Sweep origin relative to Radar Target Range/Azimuth relative to some point other than radar (cuing mode)
	6) B-Scan	Primary	Sector Selectable 1.5 nmi x 5 degrees 3 nmi x 20 degrees 6 nmi x 20 degrees
	7) Video Map	Secondary	Displays Map on PPI to show tactical situation or prominent map features

AN/TPS-61() NOT AFFECTED BY:

<u>Candidate Source</u>	<u>Rejected Because of</u>
Birds	Frequency (L-Band), MTI
Insects	Frequency (L-Band), MTI
Rain, Snow	MTI, Frequency, CPACS
Distributed Clutter	MTI, CPACS
Other Radars	Phase Coded Transmission/Reception
Moderate Masking	L-Band Diffraction
Velocity Variations of Target	Variable Interpulse Period
Helicopters (Aircraft)	Distinguishable on PPI
ECCM*	Phase Coding, MTI, VIP

*Only candidate interference source not tested.

INTERFERENCE VS COUNTERMEASURES

Ground Clutter	Chaff
Birds/Insects	CW Jamming
Pulse Jamming	Pulse Repeater
Pulse Jamming	Noise Jamming

TPS-61 Design	RF	IF	Remarks								
Frequency	X	X									L-band permits diffraction over moderate masking
CPACS	X	X	X	X	X	X	X	X	X		Most effective means of countering most jamming
Variable PRF					X						Complicates the process of a jammer locking to PRF
RF STC	X	X	X	X	X	X	X	X	X		Effective over range of STC
Preselect Filtering					X	X	X	X	X		Not effective against on-frequency jamming
MTI	X	X	X							X	Allows discrimination between fixed and moving targets on a radial velocity basis

- (1) CPACS decoder uses phase information. Random phase variations (rain, chaff, noise jamming, etc) are not correlated in the decoder and are rejected.
- (2) Only birds observed was a migratory flight at Dahlgren. This detection was easily identified.
- (3) Supported missions in rain, snow, and weather fronts at Fort Sill.

X denotes design effective against interference.

Projectile Types*



81 MM Mortar
64-261 M/S



105 MM Howitzer
198 - 474 M/S



8" Howitzer
595 M/S (Max)



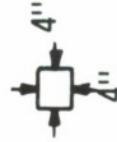
4.2" Mortar
108 - 256 M/S



155 MM Howitzer
213 - 561 M/S



175 MM Gun
914 M/S (Max)



73-0640- VB-4
4"

*To Scale

Figure 4. Projectile Types

WEAPONS EMPLOYED FOR FORT SILL TEST

The AN/TPS-61() was tested for weapon location capability against every "tube" artillery type in the US Army inventory. As illustrated, there is a wide variation in target size and velocity, two important parameters in weapon location. For the purposes of these tests, the weapons were classified into three categories: mortars, howitzers, and guns. The trajectories of these three classes have their own distinguishing features. They can be contrasted in one or more of the following parameters: range, velocity, time of flight, maximum ordinate, and variability in possible quadrant elevations. Within each class are various types; e.g., within the howitzer class are the 105 mm, 155 mm, and 8-inch howitzer types.

CAPABILITIES OF ARTILLERY WEAPONS

<u>Weapon</u>	<u>Maximum Range (Meters)</u>	<u>Elevation Limits (Mils)</u>	<u>Maximum Muzzle Velocity M/S</u>
4.2-inch Mortar	5,650	800-1,065	293
105 mm Howitzer	11,000	0-1,156	472
155 mm Howitzer	14,600	0-1,333	564
8-inch Howitzer	16,800	35-1,156	594
175 mm Gun	32,700	35-1,156	914

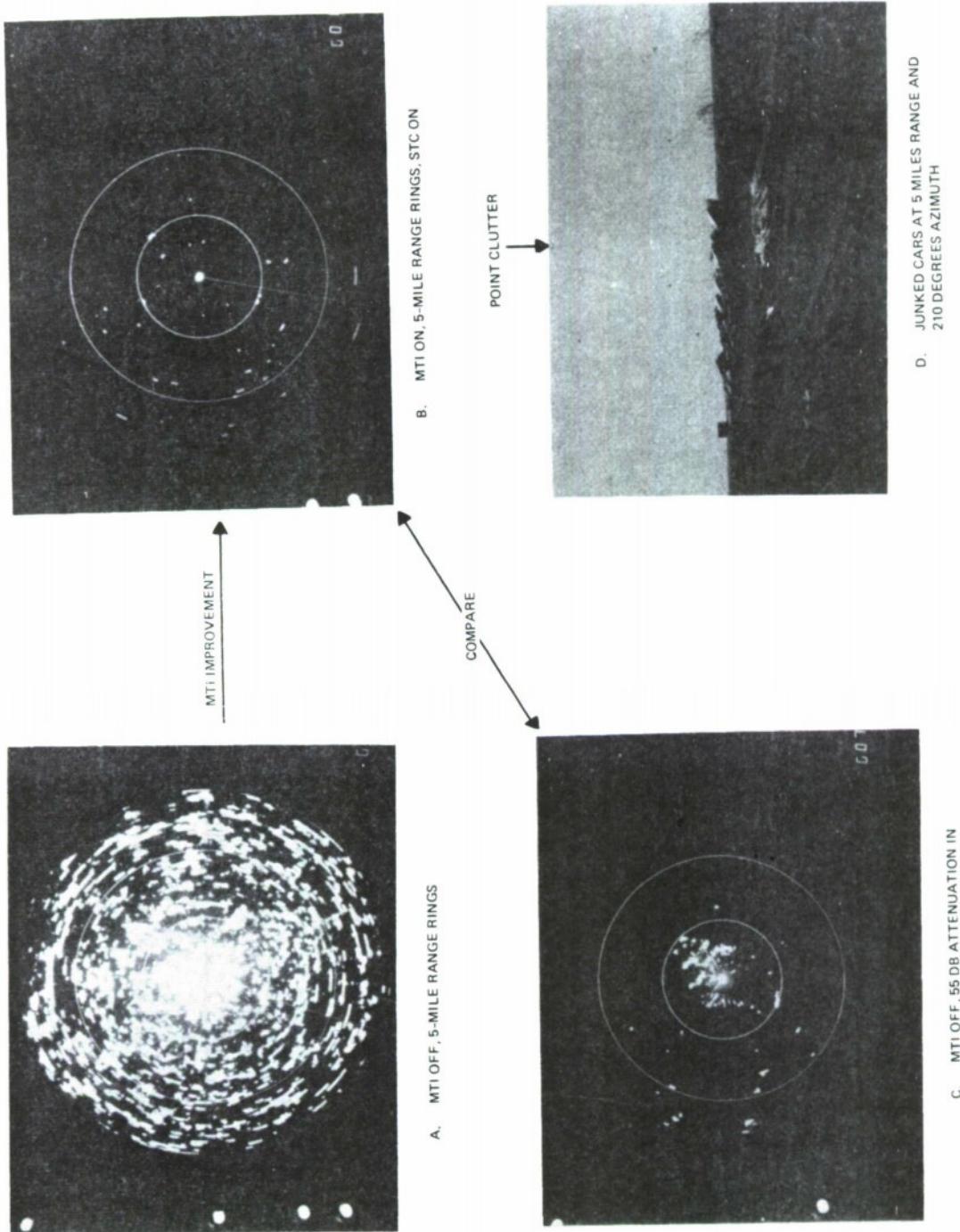


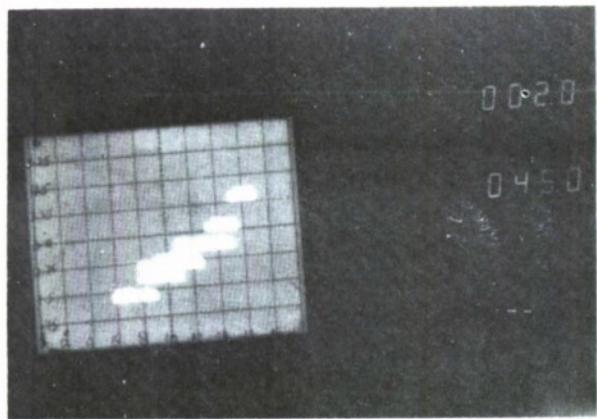
Figure 5. Fort Sill (Elgin Ridge) Ground Clutter Environment

73-0640-BB-5

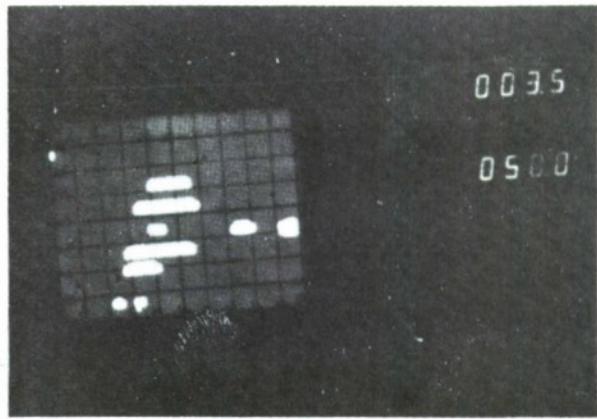
AN/TPS-61() DEMONSTRATED CLUTTER REJECTION

The clutter photographs are representative of the ground clutter environment at Fort Sill, Oklahoma. Photograph a (figure 5) illustrates the ground clutter as seen by the AN/TPS-61() with the Moving Target Indicator (MTI) and STC turned "off." It is obvious that the clutter must be removed in order to locate targets. Photograph b demonstrates the utility of MTI. The remaining points consist of moving targets and point clutter. The point clutter in this photograph consists of large water towers, a power substation, TV tower, and mountains. It cannot be determined from this single scan photograph which points are targets and which are point clutter. In actual practice, the operator studies the PPI for each new radar location, and marks or remembers the stationary returns. The process takes about five minutes. Moving targets are characterized by successive movement of the point from scan to scan. As a point of interest, the same radar located at Friendship Airport, Baltimore, Maryland presents a "black scope" except for the point clutter return from a large TV tower.

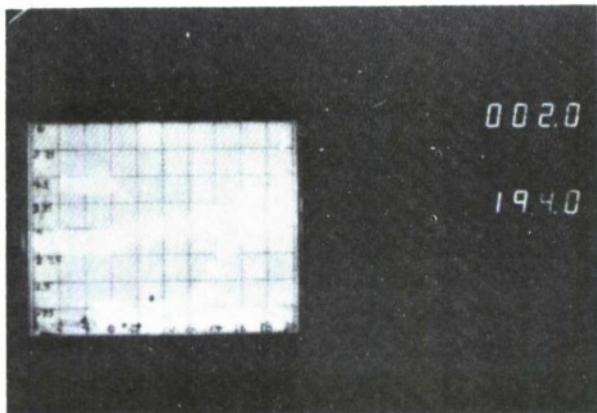
Some idea of the clutter rejection capability can be determined by attenuating the receiver with the MTI "off." Photograph c illustrates the reduction in clutter (and targets) with 55 dB attenuation placed in the receiver path. Note the similarity in point clutter in photographs b and c. Photograph d is a stockpile of junk cars which can be observed on the 5-mile range ring just to the left of the cursor in photograph b. This particular piece of point clutter was not removed from the PPI until 70 dB of attenuation was placed in the receiver.



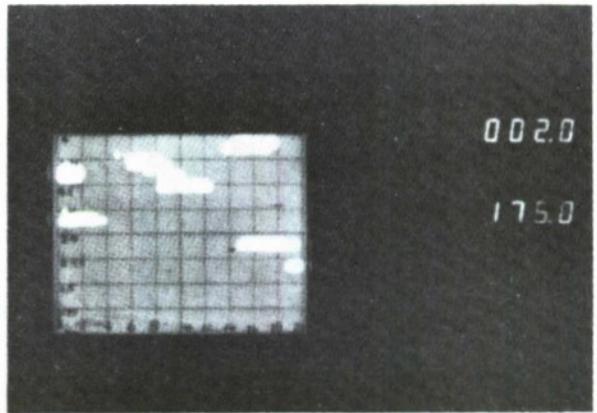
A. 105-MM HOWITZER
RANGE = 10 KM



B. 8-IN. HOWITZER
RANGE = 13 KM



C. 105-MM HOWITZER AIR BURST
RANGE = 10 KM



D. 4.2-IN. MORTAR (TOP CENTER) 13 0640 BB 6
RANGE = 14 KM

Figure 6. B-Scope Presentation of Various Single Piece Weapons

B-SCOPE PRESENTATION OF VARIOUS SINGLE PIECE WEAPONS

- View 1
 - 105 mm Howitzer
 - Test 10, Series 1, Round 25
 - Time of flight = 24 seconds
 - No. of scans = 6
 - Location error = 200 meters.
- View 2
 - 8-inch Howitzer
 - Target of opportunity
 - 50 knot peak winds
 - Rain
 - Note wider separation between scans.
- View 3
 - 155 mm Howitzer Air Burst
 - Test 8, Round 9
 - Bald Ridge central clutter across center
 - Air Burst located at bottom of display
Air Burst lasted for several scans
 - Location error = 100 meters.
- View 4
 - 4.2-inch Mortar
 - Test 3, Series 5, 2 Rounds
 - 2 successive rounds fired (top center)
 - Location error = 150 meters.

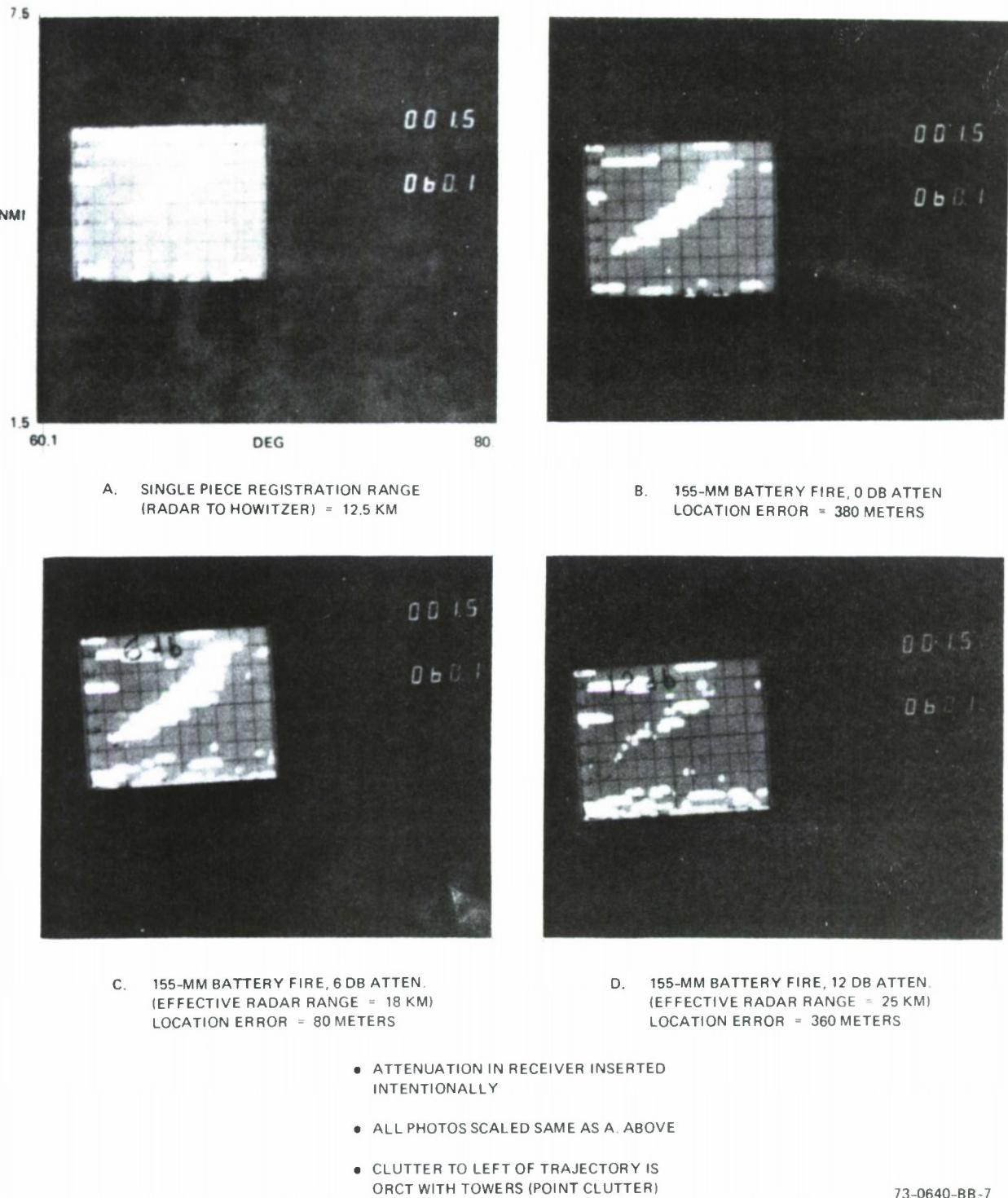
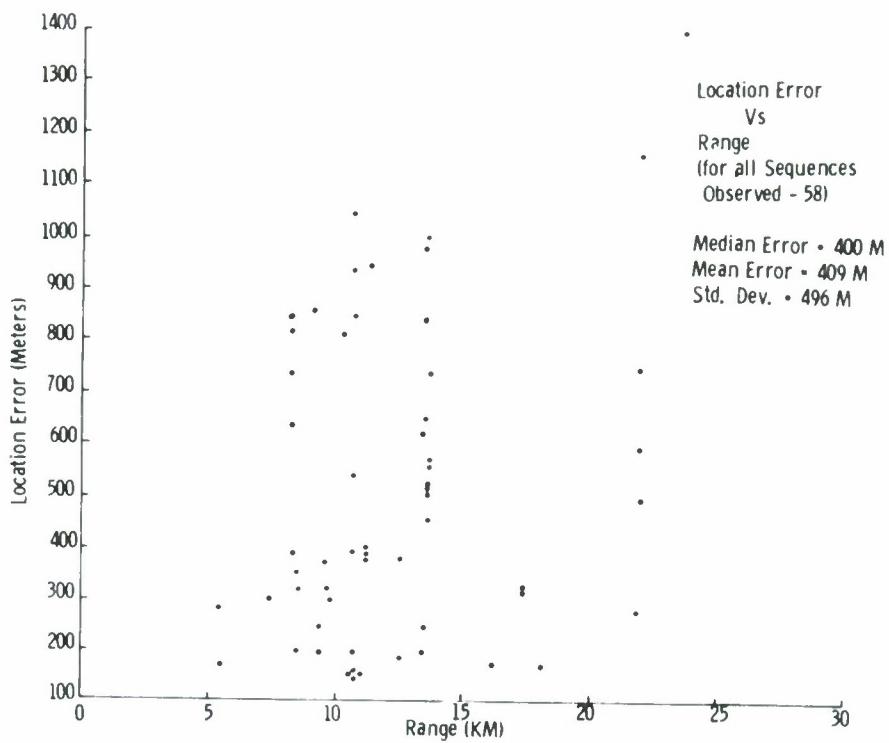


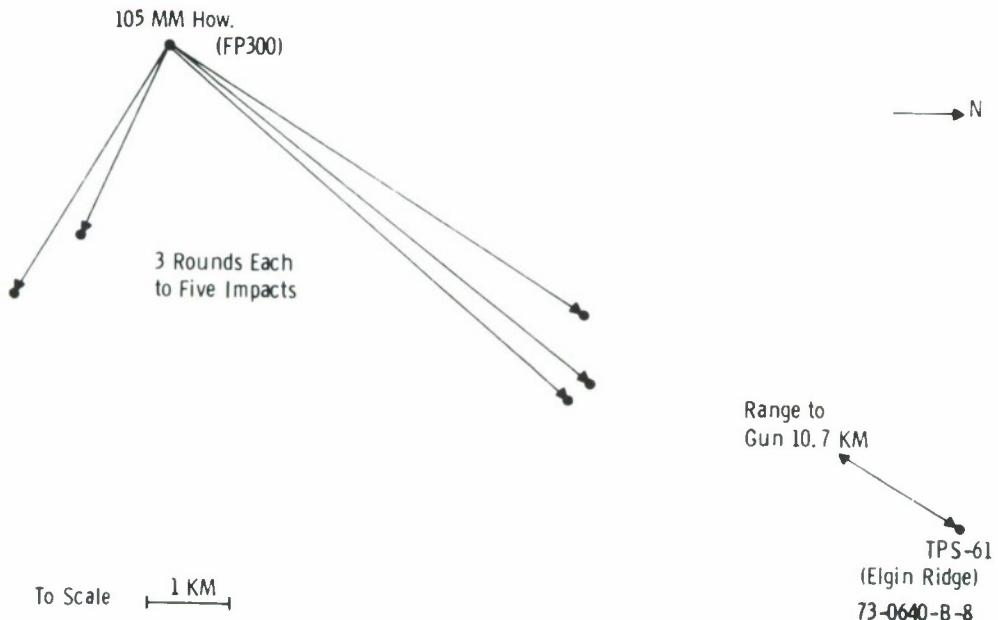
Figure 7. B-Scope Presentation of 155-mm Howitzer
Battery Location (Test 13, 2/27/73)

TYPICAL FORT SILL TEST AND ASSOCIATED SEQUENCES

- Test Period Covered - Feb. 27, 28 1973
- Test Numbers 13, 13A
 - #13 Weapon Location Known (2/27)
 - #13A Weapon Location Unknown (2/28)
- Weapon Tested - 155-mm Howitzer (M109), Battery 4, 3 Transfers
- Objective of Test - Determine 155-mm Howitzer battery location capability. Previous tests were conducted with single piece. These tests were considered representative of a tactical fire mission.
- Test Summary
 - Radar Location = POA-2
 Weapon Location = Vicinity of QRCT Area
 - Rotary joint damaged when truck hit overhang while refueling on post. High VSWR areas sector blanked off range with no loss in test significance.
 - Radar could observe and locate battery fire at 12.5 km with intentional 12 dB attenuation in receiver (effective radar range = 25 km).
 - Heavy helicopter activity observed during mission.
 - Large piece of clutter observed at fire area - identified as QRCT hill with radio towers.
 - Registrations observed prior to mission #13.
 - Typical weapon location error for unknown sequences as 280 meters.



A. Location Error Independent of Range



B. Resection Error <100 Meters for Multiple Engagements

Figure 8. Additional Test Results at Fort Sill

DEMONSTRATED ADDITIONAL CAPABILITIES OF AN/TPS-61()

• Location Beyond Maximum Effective Range of Weapon

<u>Weapon</u>	<u>Demonstrated Location*</u> <u>Range at Fort Sill (km)</u>	<u>Maximum Effective Range (km) of WPN</u>
81 mm Mortar	5.4	4.5
4.2-inch Mortar	22	5.6
105 mm Howitzer	13.7	11.5
155 mm Howitzer	27**	14.6
8-inch Howitzer	18.1	16.8

*Does not imply maximum detection range

**Target of opportunity

• Classify Weapon Type

<u>Sequence</u>	<u>WPN***</u>	<u>Classed</u>	<u>No of Rounds Required</u>	<u>Derived Velocity M/S</u>	<u>Actual Velocity M/S</u>
1	155 mm Howitzer	Howitzer	1	243	204
2	4.2-inch Mortar	Mortar	1	130	136
3	105 mm Howitzer	Howitzer	4****	---	---
4	175 mm Gun	Gun	1	.460	494

***Sequence and Weapon Not Known A Priori

****Transmitter "CROWBAR" at start of test

- Location Error Independent of Range - The major contribution to accuracy appears to be in point clutter obscuring part of the trajectory. Most of the points in the upper part of figure (1) were caused by this condition. The 1,400 meter error (worst location error) was due to the trajectory being over Signal Mountain.
- Resection Capability - Using resection techniques (figure 2) and the B-scope display during test 5, it was possible to locate the hostile weapon to within 100 meters. This was accomplished by recording the intersection of various trajectories during the five target engagement.

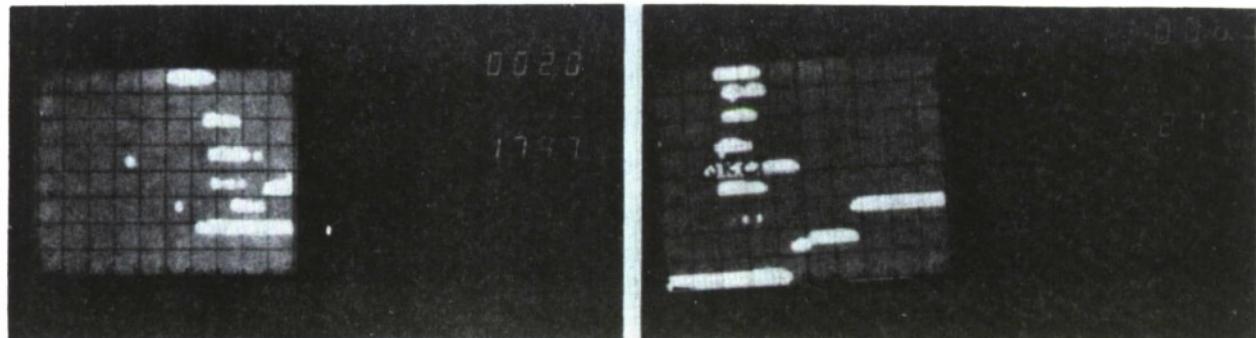
THE ELUSIVE 175 MM GUN

<u>Mission</u>	<u>Range to Gun (km)</u>	<u>Blip Scan Ratio %⁽¹⁾</u>
4-4	13.7	90
15, 16	31	0
17	24 (Impact Range) ⁽²⁾	64 (last 1/2 of trajectory) ⁽³⁾

(1) Based upon time of flight and scan rate

(2) 175 mm fired away from radar

(3) High swept mode inoperative (blind speed problem)



A 175-MM GUN, TEST 4-4

B 175-MM GUN, TEST 17

73-0640 BC-9

Figure 9. B-Scope Presentations

OBSERVATIONS OF 175 MM GUN FIRINGS AT FORT SILL

Three separate tests were conducted with the 175 mm gun. The only missions where no radar detections were observed, occurred during the long range weapon location tests (15, 16). In fact, forty rounds were fired over a two-day period with no radar detections except for impact. There was sufficient time between rounds to place the radar in various modes: antenna tilt variation, scan/searchlight, variable threshold settings (video integrator), final transmitter stage "on/off," and pulse compression "on/off." While no firings were observed for the 175 mm gun, a 155 mm howitzer at 27 km range was observed and located during the tests. This was later verified by consulting the Fort Sill daily firing schedule. The radar appeared to be operating normally; consequently, the only explanation seems to be one of radar cross section for this particular mission. For weapons of this class the radar cross section can vary as much as 50 dB depending upon aspect, pitch, and roll. Target radar cross sections of -50 DBSM ($1/100,000 \text{ m}^2$) can be expected. The other 175 mm gun missions gave excellent radar detections.

175 MM GUN MISSION DATA

Mission	MV (m/s)	QE (mils)	TOF (sec)	Radar Location
4-4	511	266	31	Elgin Ridge
15, 16	914	541, 560	70, 72	Post Oak Area
17	704	680	67	Gate House Area

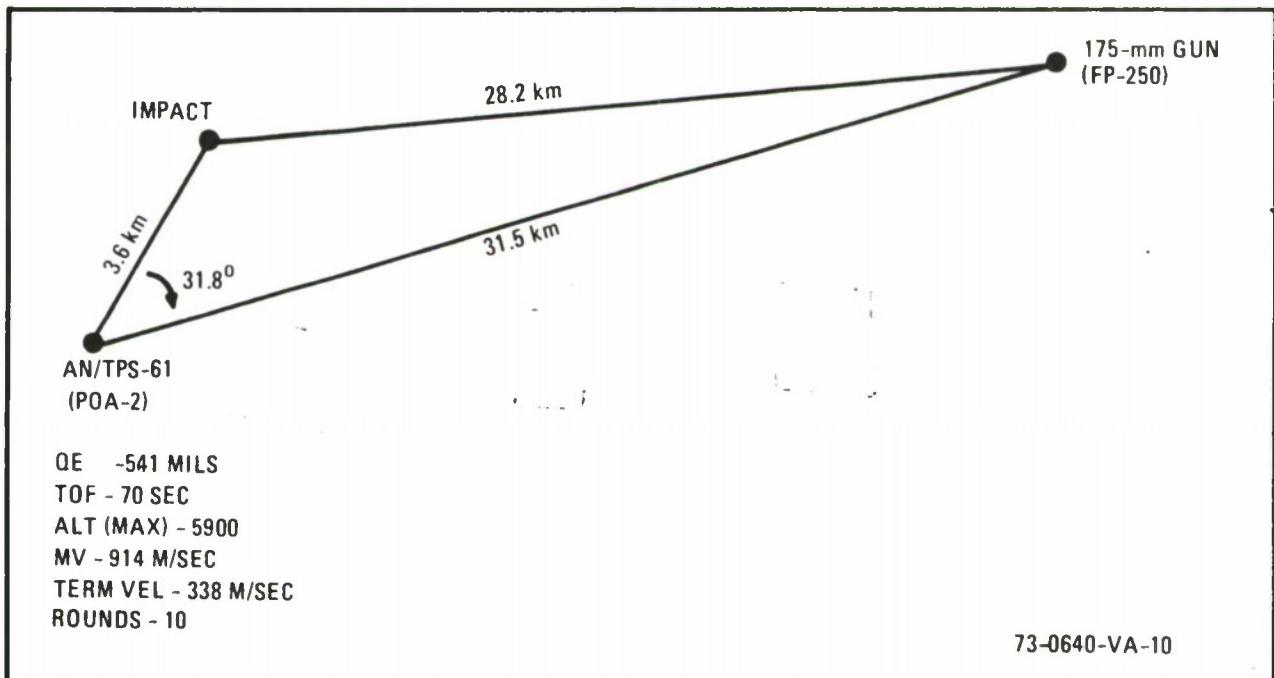


Figure 10. Geometry and Firing Data, Test 15

AN/TPS-61() CAN ESTIMATE QE AND CHARGE

Weapon	Actual		Operator Estimate*	
	QE (mils)	Chg	QE (mils)	Chg
8-inch Howitzer	671	7	590	7
	518	7	524	7
155 mm Howitzer Battery	305	6	320	6
	349	6	370	6
	331	6	370	6
105 mm Howitzer	566	4	300	4
	525	4	320	1
	449	4	320	1
105 mm Howitzer	456	4	370	4
	536	4	290	4
105 mm Howitzer	317	6	370	6
	357	5	340	5
	417	4	310	4
	276	3	360	2
	297	3	360	2
	264	2	330	1

*All Unknown Missions Except Mortars.

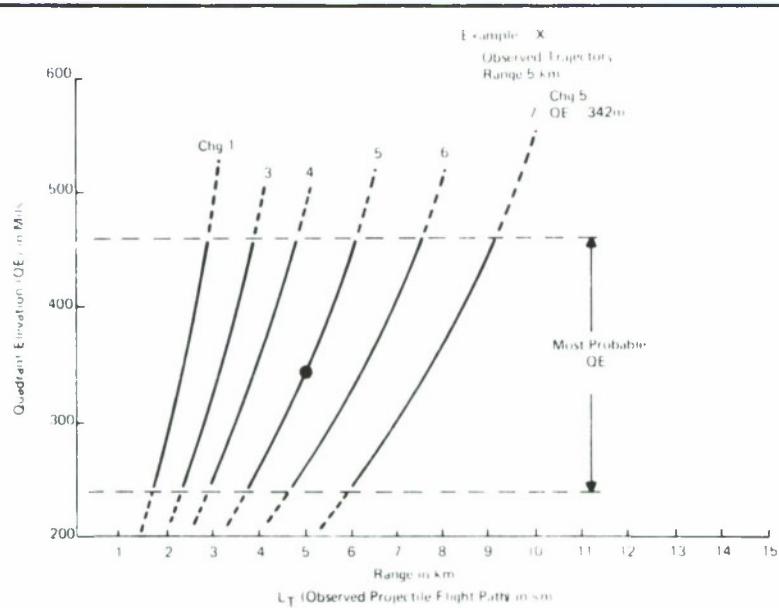
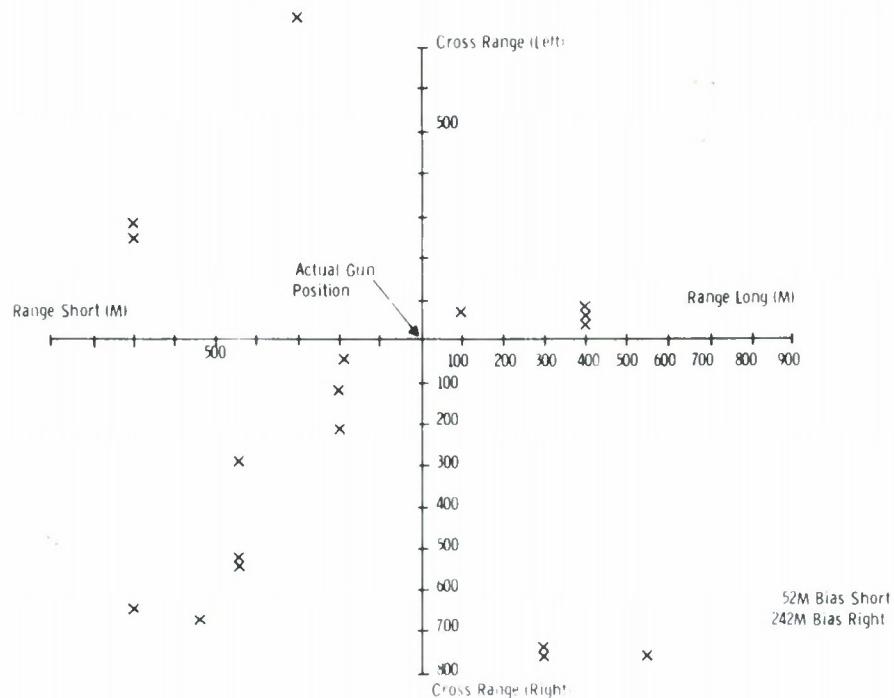


Figure 11. Estimation of QE and Charge

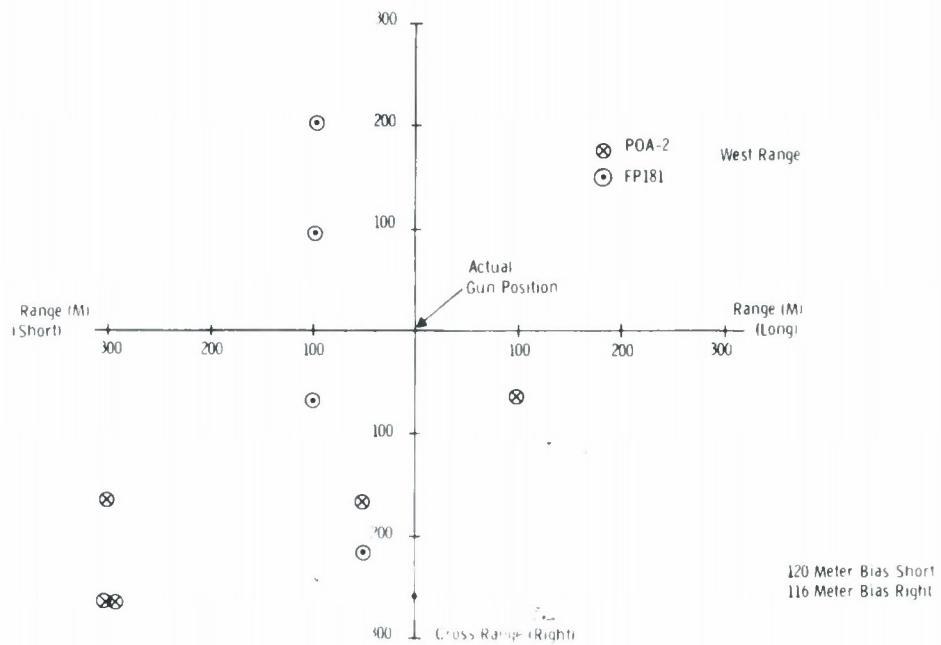
ESTIMATION OF QE AND CHARGE FROM RADAR OBSERVATIONS

As part of the computer corrections to raw radar data, it was required to estimate weapon QE and charge (muzzle velocity). This is accomplished by observing the gun trajectory ground range (weapon to impact range) on the B-scope. The observed projectile flight path length indicates a best or more probable weapon charge and QE. A series of graphs similar to the one shown were prepared for each weapon type. As an example, if the weapon range observed was 5 km, then the most probable charge was five and the QE was 342 mils. Of course, charge six and low QE or charge four and high QE could have been used. However, it is typical for howitzers to use QE's from 240 to 460 mils.

The table presents a comparison of the operator's estimate of QE and charge and the actual gun data. The data presented is for unknown missions with the exception of mortars. The reason mortars are not listed is that the 4.2-inch mortar was fired at 900 mils for all tests. Range variation for the 4.2 inch is accomplished by varying charge rather than QE. Of the 16 missions, 11 estimates of charge were in agreement. The two large discrepancies in charge (4 vs 1) was due to the radar not observing a large portion of the trajectory. Point clutter obscured part of the trajectory; consequently, a short gun range was assumed which resulted in a lower estimate of charge and QE.



A. Range and Cross-Range Errors, East Range



B. Range and Cross-Range Errors, West Range

73-0640-BC-12

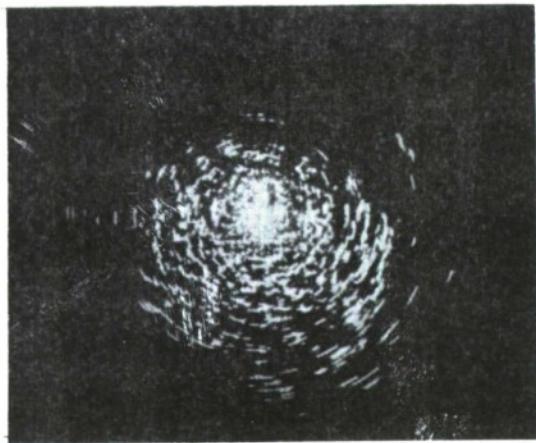
Figure 12. Range and Cross-Range Errors of Unknown Sequences

BIAS ERRORS IN WEAPON LOCATION ESTIMATION

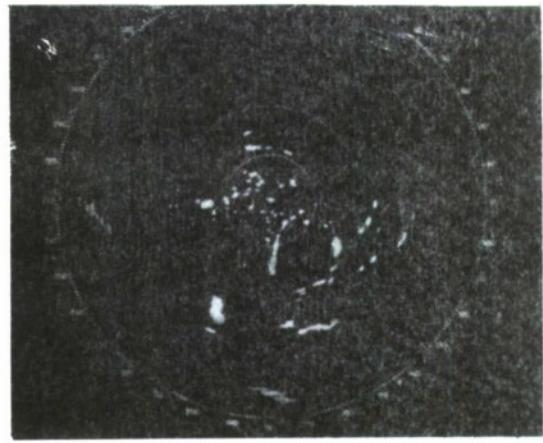
The location errors described in this report are the length of the line segment between the radar estimate and the actual weapon location. This analysis gives some insight into the range and cross-range components of the line segment. Figure 12 presents these errors for unknown sequences at three different radar sites. The range error is referenced to the radar-gun line and the cross-range error is a function of the azimuth estimate and radar-gun range. For the unknown sequences there appears to be a bias right and short.

The data used for this analysis was the raw radar data. Computer correction actually increased the errors in location estimation. The errors in the east range data are larger than the west range data primarily because of point clutter obscuring the initial part of the trajectory. More point clutter existed for the east range tests. While not shown in this data, the location error was found to be independent of range.

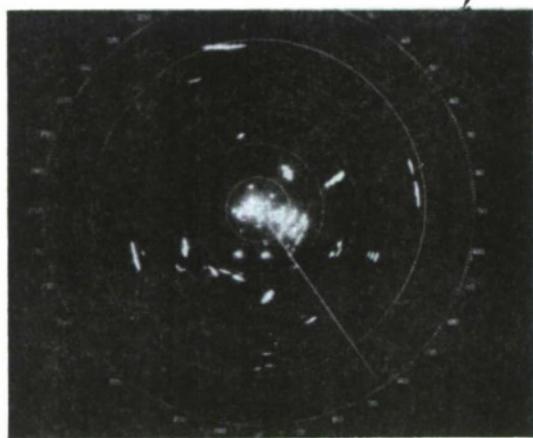
Much of the range bias could be removed by correcting only for non-synchronous radar scan (see Annex III). For the west range data, the average scan correction is 177 meters added to the raw radar data. The correction for the east range data would be smaller due to the preponderance of mortar missions which have higher QE and lower muzzle velocity. The azimuth bias would be reduced by optical calibration and shortening the variable interpulse period from 16 to 8 pulse repetition intervals. Both of these improvements are recommended in future designs.



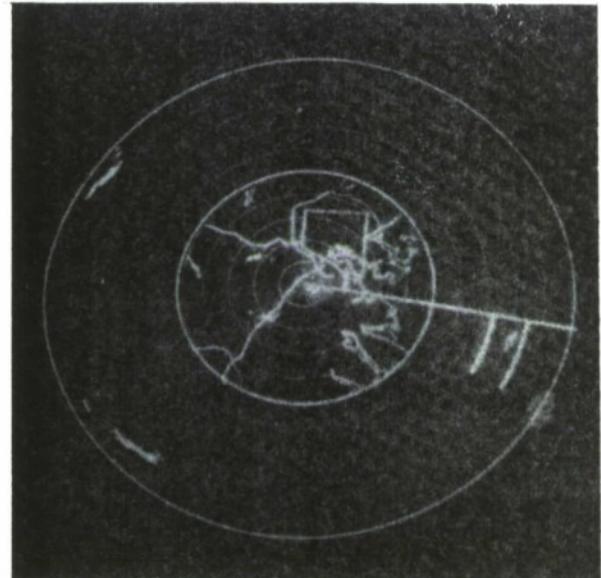
A. MTI OFF, 20 NMI RANGE (SINGLE SCAN)



B. MTI ON, 20 NMI RANGE (20 SCANS, NOTE AIRCRAFT LANDING AT LAWTON AIRPORT)



C. MTI ON, 60 NMI RANGE (20 SCANS)



D. MTI ON, 50 NMI RANGE (MULTIPLE SCAN PHOTO WITH VIDEO MAPPER PRESENTATION, TAKEN AT FRIENDSHIP AIRPORT, BALTIMORE, MARYLAND. NOTE OUTLINE OF CHESAPEAKE BAY)

73-0640-B-13

Figure 13. PPI Presentation of AN/TPS-61() in ASR Mode

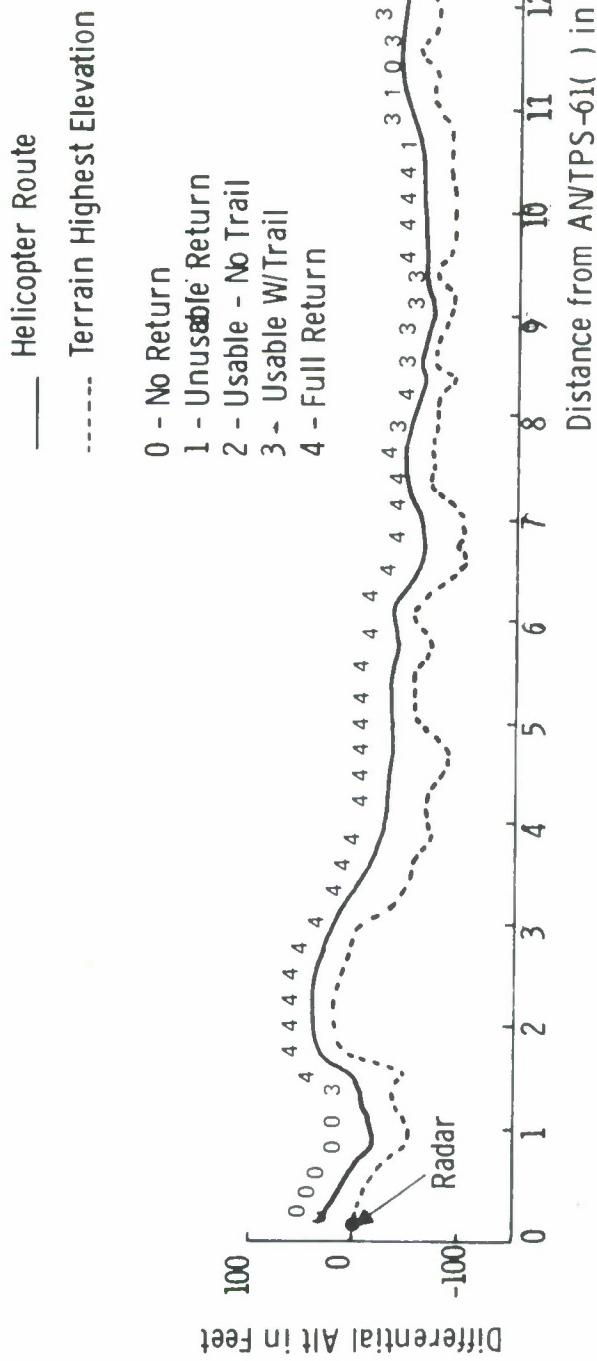
AN/TPS-61() AIR SURVEILLANCE RADAR MODE

The AN/TPS-61() was also tested at Fort Sill for its ASR capability. To change from the weapon location mode to the ASR mode, it is only necessary to change the range scale on the PPI. The ASR mode can be used for surveillance of aircraft to assure the effective use of airspace, vectoring aircraft to provide separation and radar navigation, and coordination of artillery supporting fires and aviation activities.

View (1) shows the radar clutter for a 20 mile radius, single scan, and MTI "off" at Fort Sill, Oklahoma. The lack of clutter returns to the north is due to the terrain masking of the Wichita Mountain range. View (2) is a display of the same area for 20 scans with the MTI "on." Most of the remaining points are from targets of opportunity. Note the approach of an aircraft (due south) into the Lawton Municipal Airport. View (3) is for 60 nautical mile (radius) coverage from the same location. View (4) is a multiple scan photo taken in the Baltimore, Maryland area. The outline of Baltimore and the Chesapeake Bay area is presented on the PPI with the aid of the OA-8554/G video mapper. Note that there is less clutter return in the Baltimore area than at Fort Sill, Oklahoma, which is to be expected. Aircraft have been observed at Fort Sill at ranges of 130 nautical miles.

ASR Flight Test

Flight Test ANTPS-61() - Radial
Fort Sill, Oklahoma 16 Feb 1973
Aircraft UH-1H (80 Knots)



AN/TPS-61() ASR TESTS

Under the direction of the US Army Aeronautical Services Office (USAASO), the AN/TPS-61() was tested during the Fort Sill tests. The test was planned, coordinated, and conducted under their control. The purpose of the test was to determine the capability of the radar to detect low flying helicopters in a ground clutter environment.

For the purposes of the test, a UH-IH (Iroquois) helicopter was flown at 25 feet above local terrain at 80 knots in a radial path from the radar. The qualitative performance figures (denoted by zero to four entries) on each scan are the judgement of a qualified air traffic controller from USAASO. The trail mentioned in judgements 2 and 3 relate to the persistence of the PPI on the preceding scan. Additional tests dealing with tangential flights (with respect to the radar) are presented in the annexes. As illustrated, the target could be observed below optical line of sight, as was the case in weapon location. On numerous occasions, aircraft were observed at ranges in excess of 100 nautical miles without changing from the weapon location radar mode, except for PPI scale.

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DAHLGREN (NWL) TEST - SYSTEM FAMILIARIZATION

- Shakedown for Fort Sill Test

- Refine operating procedures
- Debug radar modifications
- Train radar crew
- Verify theoretical detection of projectiles
- Systematize azimuth alignment procedures
- Determine effectiveness of various radar modes.

- Environment

- Projectile trajectory over water
- Weapons fired exclusively from high point clutter area
- Numerous point clutter returns (towers, bridges, and reflectors).

- Utility of Tests

- Verified detection at ranges of 23 km (5 inch and 81 mm)
- Improved reliability of radar prior to Fort Sill tests
- Acquired appreciation for coordinated conduct of tests
- Finalized reporting procedures of test results
- Reduced number of surprises at Fort Sill.

FAMILIARIZATION WITH PROJECTILE DETECTION TESTS

After the basic AN/TPS-61 was modified for a weapon location capability, a shakedown test was performed at the Naval Weapon Laboratory at Dahlgren, Virginia. The close proximity to the Westinghouse plant and numerous targets of opportunity made this location ideal for the test objective. Approximately four weeks were spent at Dahlgren prior to proceeding to the more formal test period at Fort Sill, Oklahoma.

It was recognized early that the environment was not typical (fixed firing point, operation over water, and numerous man-made clutter structures); however, the primary objectives were met. Equipment deficiencies were corrected and the radar crew was trained during this period. It was noted that weapons firing from large point clutter areas (exclusively the case at Dahlgren) had part of their trajectory obscured. This was reconfirmed during the Fort Sill tests (see figure 5). In order to get a weapon location estimate it was necessary to reduce the radar pulselwidth from 26 μ sec to 4 μ sec. This technique proved useful at Fort Sill in locating mortar firings near point clutter areas.

The tests against primarily targets of opportunity, indicated a need for additional training and practice prior to proceeding to Fort Sill. This was accomplished by using a programmed target simulator, realistic target display, and map exercises. Scenarios were generated for various classes of weapons (mortar, howitzer, and gun) using the Fort Sill maps with planned radar locations to obtain weapon location estimates. Improved reporting and documentation procedures also resulted from this useful exercise.

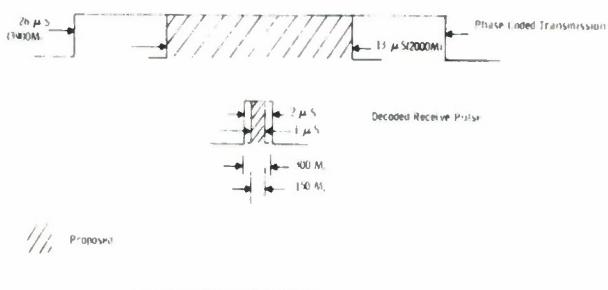
SIGNIFICANT PERFORMANCE IMPROVEMENT WITH NO IMPACT ON PRODUCTION COSTS

- Reduce Point Clutter Capture
- Double Data Rate of Scan
- Improve Mortar Location Capability
- Reduce Azimuth Smear
- Reduce Emplacement Time
- Improve Dynamic Range of Receiver
- Reduce Operator Reaction Time and Chance for Error
- Provision for Multiple Engagement Location.

RECOMMENDED SYSTEM IMPROVEMENTS TO AN/TPS-61()

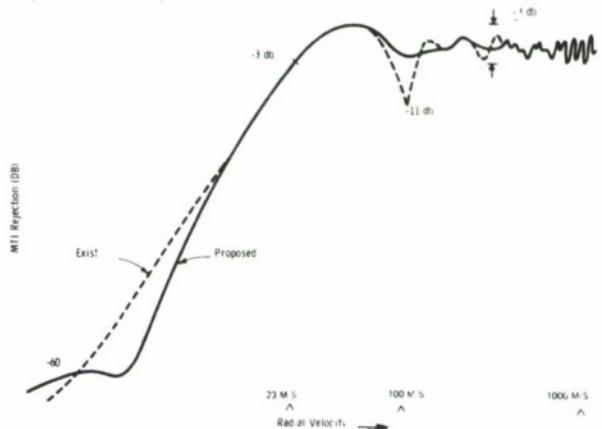
<u>Improvement</u>	<u>Accomplished By</u>
Reduction of point clutter capture and clutter effects	Reduce Barker code transmission and reception to 13 and 1 μ sec respectively
Double data rate of scan	Increase scan rate to 30 rpm
Improve mortar location capability	Reduce alternate transmit mode to 1 μ sec and remove first blind speed notch by variable weighting of coefficients
Reduce azimuth smear	Install top level limiter in digital integrator
Reduce emplacement time and eliminate need for surveyed towers	Provide optical scope for azimuth calibration
Improve dynamic range of receiver from 54 to 66 dB	Install 12 bit A/D converter in receiver
Reduce operator reaction time and change for error	Install B-scope cursor
Provision for multiple engagements	Install several addressable B-scopes

CPACS IMPROVEMENT



a. Increase Radar Bandwidth (Reduce Clutter Effects)

Improved MTI Response



b. Improved MTI Velocity Response (Improve Mortar Location 55 to 255 M/sec Muzzle Velocity)

73-0040-BC-15

Figure 15. CPACS and MTI Improvement

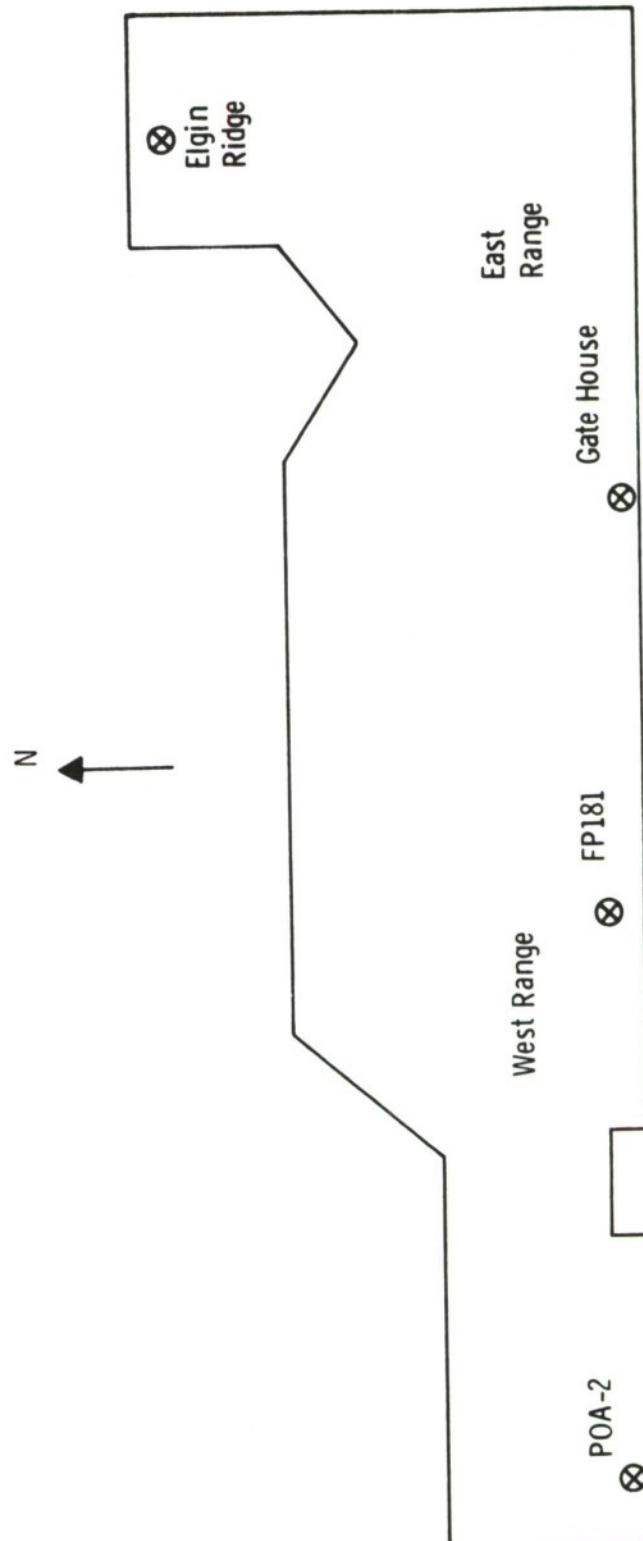
GLOSSARY OF TERMS

ASR	- Air Surveillance Radar
B-Scope	- Video display in range and azimuth coordinates (sector expansion of PPI) - rectangular coordinate system
Blip Scan Ratio	- Ratio of number of scans observed to possible number for a given time of flight
Btry	- A <u>Battery</u> for test purposes is six guns under one unit.
CEP	- Circular Error Probability - radius of the 50 percent probability circle
CFA	- Cross Field Amplifier (final transmitter stage)
Charge	- Amount of propellant used to vary muzzle velocity
Confirm	- Test where complete data supplied prior to mission
CPACS	- Coded Pulse Anti-Clutter System - Uses phase coded pulse (13 bit Barker Code - pulse compression)
CSC ²	- Cosecant-squared antenna pattern where power radiated is proportional to CSC ² θ , where θ is the elevation angle
CUE	- Functional capability for handing over target position to another sensor
DBSM	- dB relative to one square meter
Distributed Clutter	- Natural terrain excluding point clutter
FP	- Firing Point
Locate	- Test where no a-priori information given except weapon type, approximate time, and general area
Location Error	- Distance between TPS-61 estimate and actual weapon location (length of line segment)
Mask	- Natural terrain obstacle which is optically above local horizon

GLOSSARY (Continued)

MDS	- Minimum Detectable Signal
MIL	- 1/6400 of a circle (1 degree = 17.7 mils)
MTI	- Moving Target Indicator, a device to reject unwanted clutter
Point Clutter	- Large fixed obstacles - towers, bridges, mountains, etc
PPI	- Plan Position Indicator - polar coordinate display of range and azimuth
QE	- Quadrant Elevation (see FM 6-40, p. 2-11)
Searchlight	- Radar azimuth controlled by operator
Sequence	- Variation in test, usually one parameter changed. Parameter may be location, impact point, weapon type, etc
STC	- Sensitivity Time Control varies the sensitivity of the receiver as a function of radar range
Test	- Specific objective to determine capability
TIS	- Test Information Sheet, a concise description of test events and data
TOF	- Time of flight
WPN	- Abbreviation for weapon

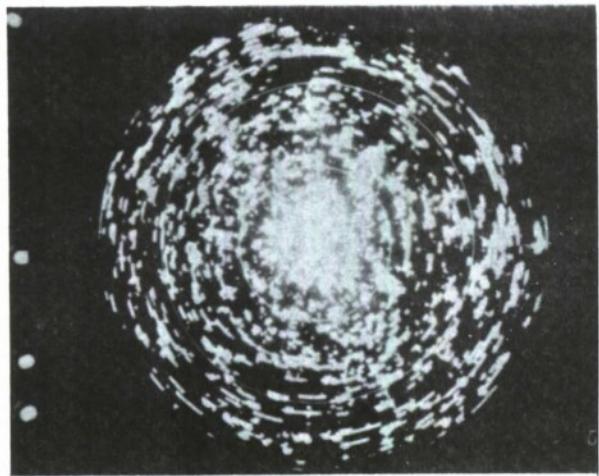
RADAR SITE LOCATIONS AT FORT SILL, OKLA



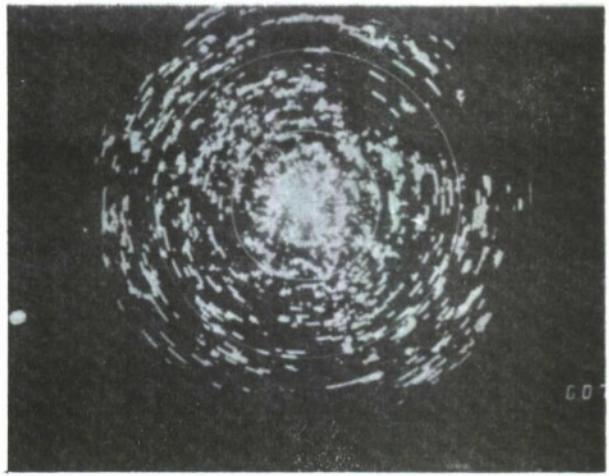
Scale _____ 3 KM

73-0640-VB-16

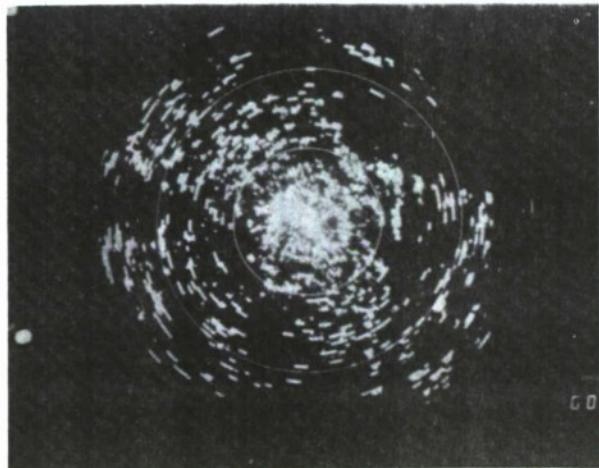
Figure 16. Radar Site Locations at Fort Sill



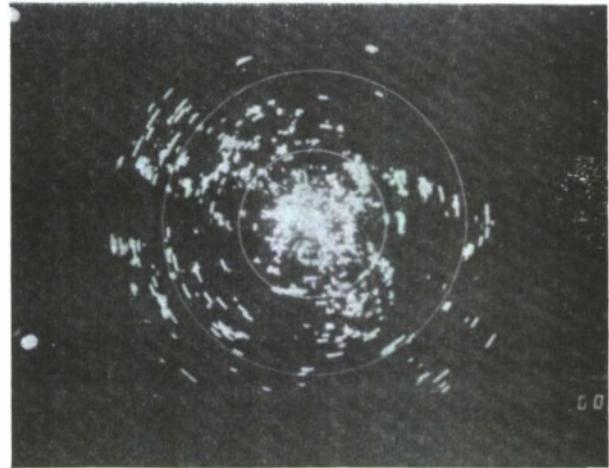
A. MTI OFF, 0 DB ATTEN



B. MTI OFF, 10 DB ATTEN



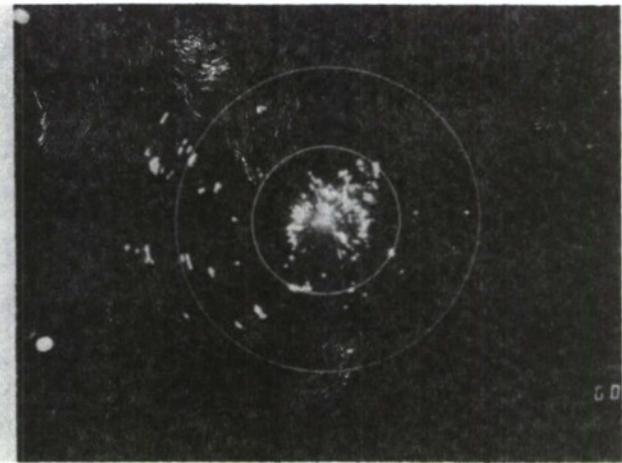
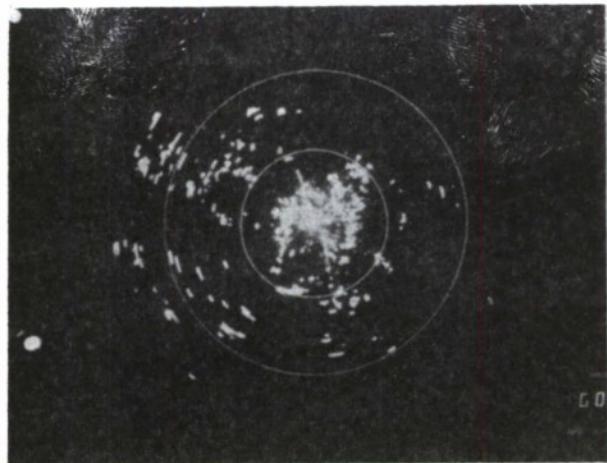
C. MTI OFF, 20 DB ATTEN



D. MTI OFF, 30 DB ATTEN

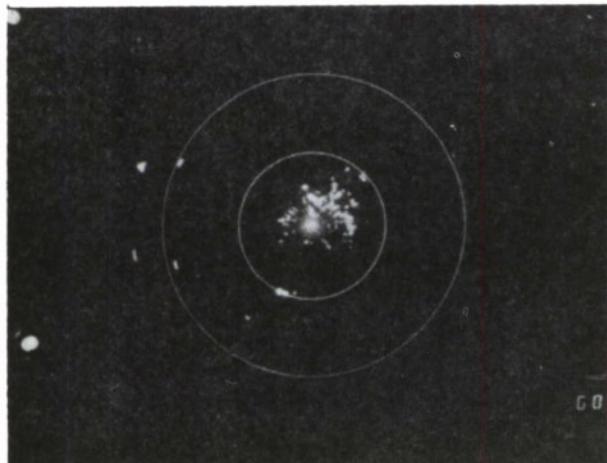
73-0640-BB-17

Figure 17. Clutter Maps, East Range (Elgin Ridge)
(5 nmi Range Rings)

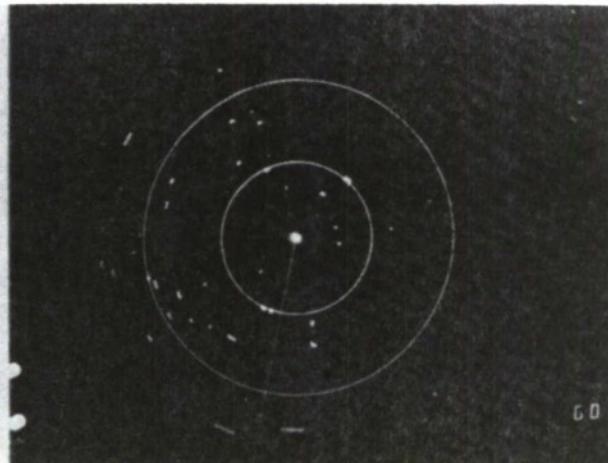


E. MTI OFF, 40 DB ATTEN

F. MTI OFF, 50 DB ATTEN



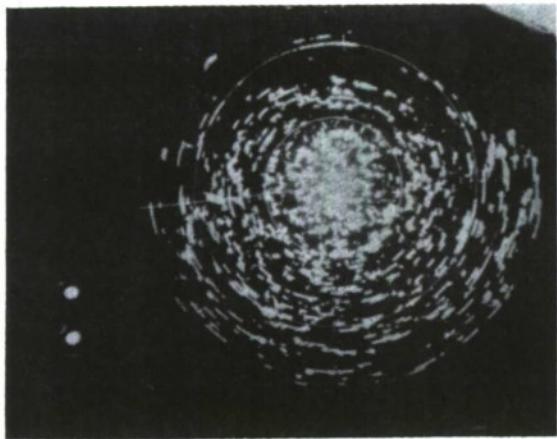
G. MTI OFF, 60 DB ATTEN



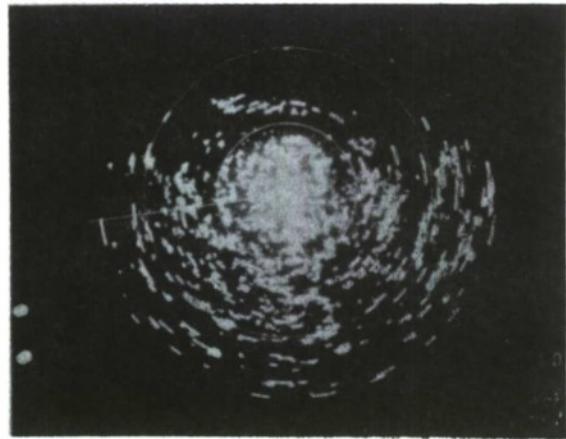
H. MTI ON, STC ON

73-0640-BB-18

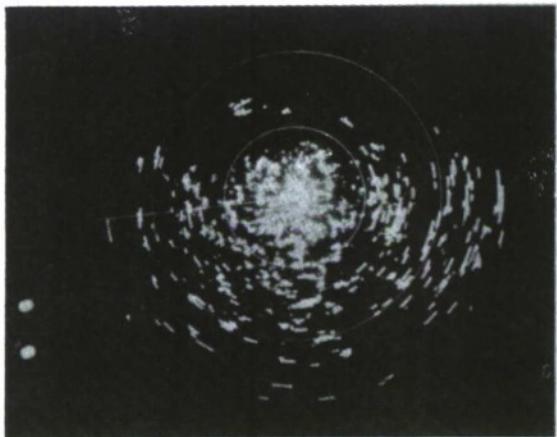
Figure 17. Continued



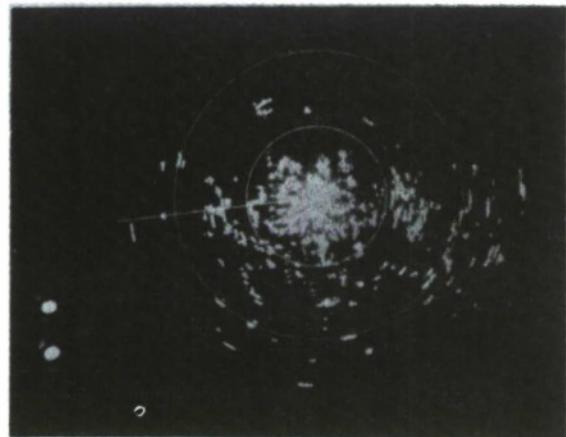
A. MTI OFF, 0 DB ATTEN



B. MTI OFF, 10 DB ATTEN



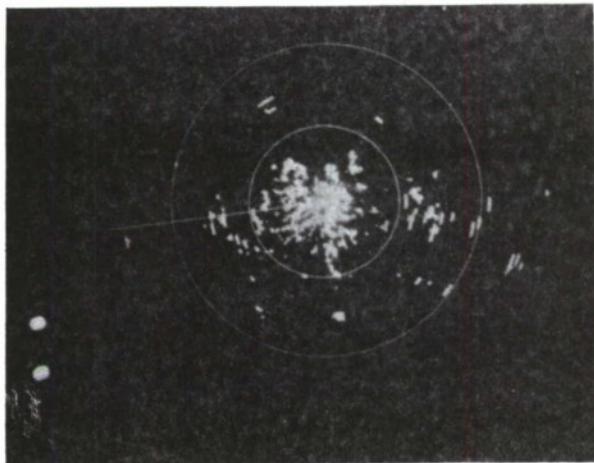
C. MTI OFF, 20 DB ATTEN



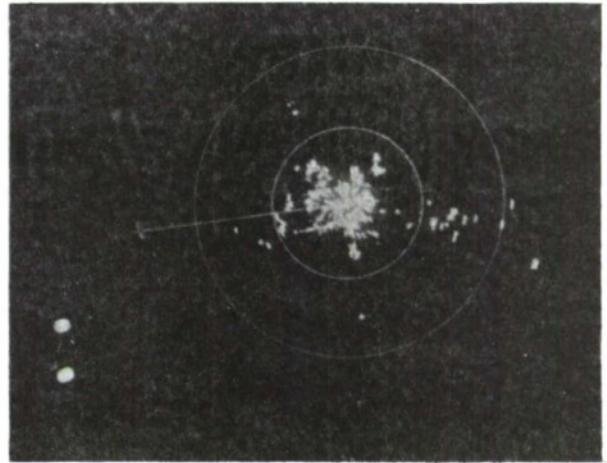
D. MTI OFF, 30 DB ATTEN

73-0640-BB-19

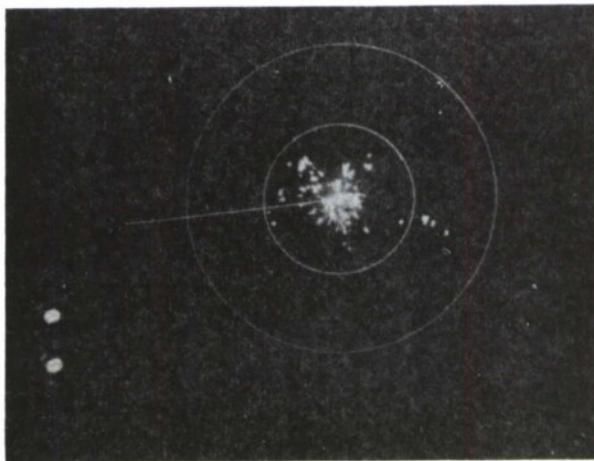
Figure 18. Clutter Maps, West Range (FP181)
(5 nmi Range Rings)



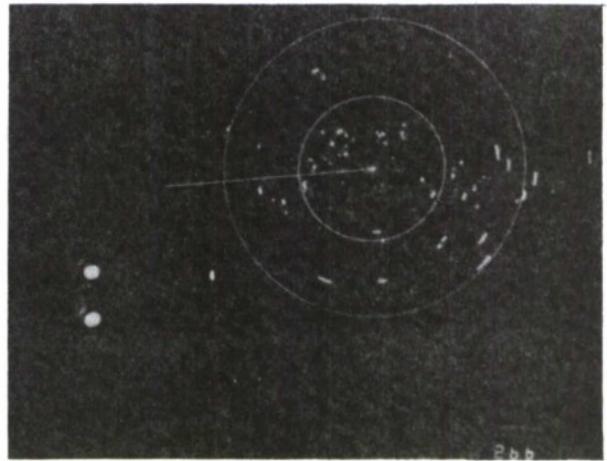
E. MTI OFF, 40 DB ATTEN



F. MTI OFF, 50 DB ATTEN



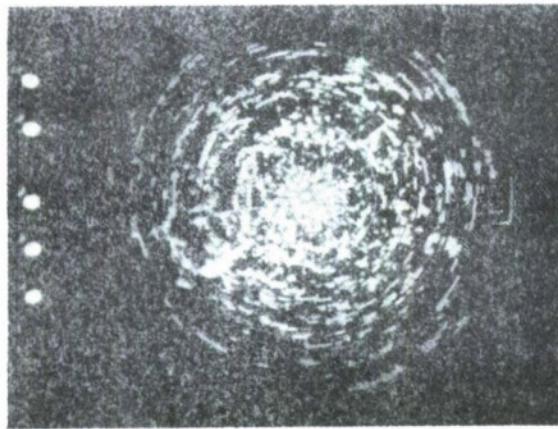
G. MTI OFF, 60 DB ATTEN



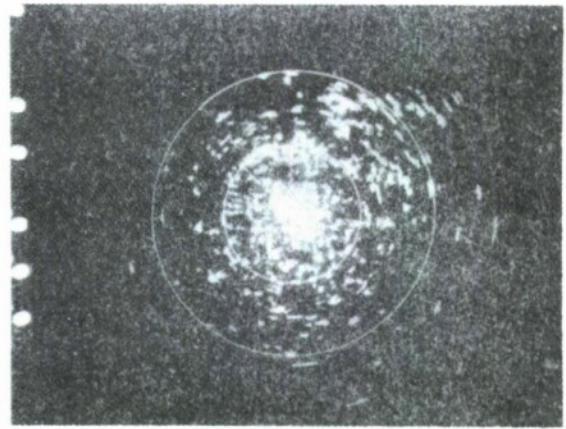
H. MTI ON, STC ON, SINGLE SCAN

73 0640-BB-20

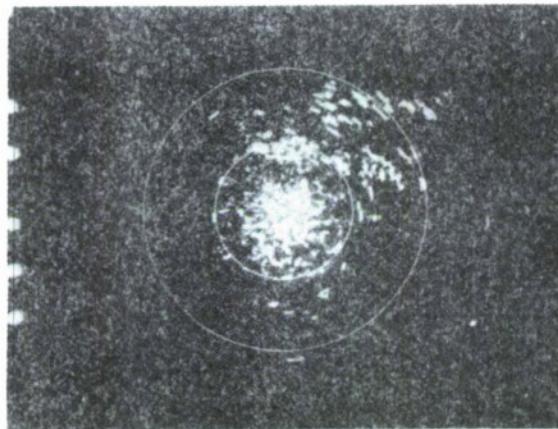
Figure 18. Continued



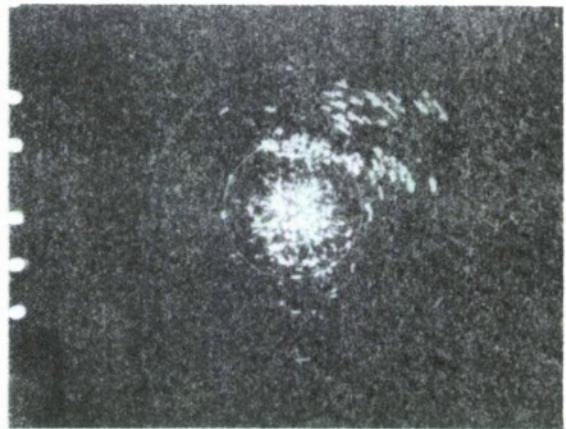
A. MTI OFF, 0 DB ATTEN



B. MTI OFF, 10 DB ATTEN



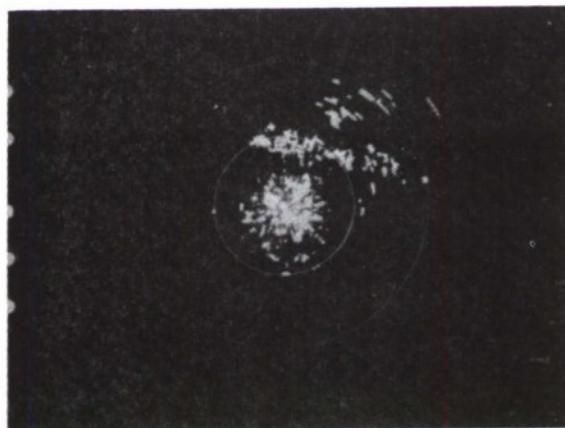
C. MTI OFF, 20 DB ATTEN



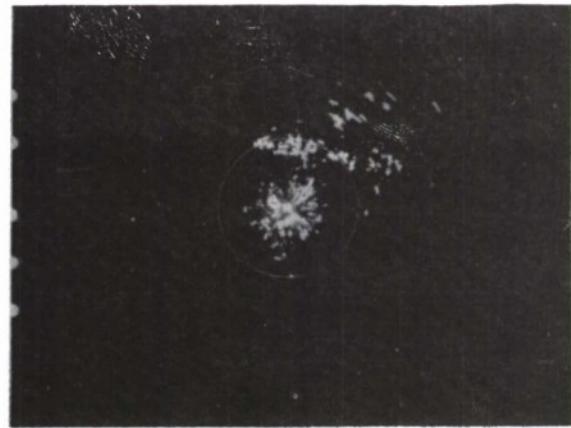
D. MTI OFF, 30 DB ATTEN

73-0640-88-21

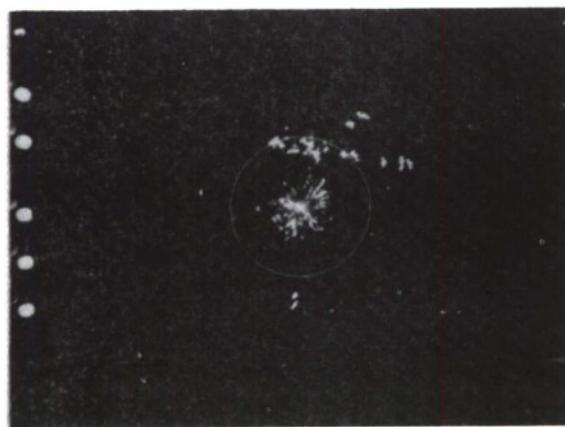
**Figure 19. Clutter Maps, Post Oak Area (POA-2)
(5 nmi Range Rings)**



E. MTI OFF, 40 DB ATTEN



F. MTI OFF, 50 DB ATTEN



G. MTI OFF, 60 DB ATTEN



H. MTI ON, STC ON, SINGLE SCAN

73-0640-BB-22

Figure 19. Continued

VARIATION IN FORT SILL TESTS

- Weapons

	<u>Range (km)*</u>	<u>QE (mils)</u>	<u>Charge</u>
81 mm Mortar	5.4	1004, 1020	7
4.2-inch Mortar	5.4 to 23.4	900	12 to 24
105 mm Howitzer	7.3 to 13.7	221 to 566	1, 2, 3, 4, 5, 6, 7
155 mm Howitzer	10.7 to 13.7	305 to 458	2, 4, 6
8-inch Howitzer	16.3 to 18.1	518 to 671	6, 7
175 mm Gun	13.7 to 31	266, 541, 560	1, 3, 2

* Range from Radar to Gun

- Radar Site Masking

<u>Site</u>	<u>Prominent Terrain</u>	<u>Variation (mils)</u>
Elgin Ridge	None	0
FP181	Signal Mountain, McKenzie Hill	5 to 27
Post Oak Area (POA-2)	QRCT and West Range Mountains	9 to 27
Gate House Area	QRCT, Signal Mountain, McKenzie Hill	0 to 4

ANNEX I. WEAPON TEST DATA AT FORT SILL, OKLA.

<u>Date (1973)</u>	<u>Test</u>	<u>Weapon</u>	<u>FP</u>	<u>QE (miles)</u>	<u>Charge</u>
1/23	2	4.2 in.	497	900	17 12 6/8 19 2/8 13 2/8 19
1/23	2A	4.2 in.	351	900	17 20 4/8 15 4/8 19 17 4/8
1/24	3B (Unk)	4.2 in.	170	900	14 4/8 16 17 4/8 19 4/8 19
1/24	2B	4.2 in.	174	900	22 21 4/8 24 22 4/8 22 4/8
1/26	3 (Unk)	4.2 in.	524	900	13 4/8 15 4/8 20 4/8 17 12 4/8
1/26	3A (Unk)	4.2 in.	415	900	12 18 4/8 16 19 4/8 16

<u>Date (1973)</u>	<u>Test</u>	<u>Weapon</u>	<u>FP</u>	<u>QE (mils)</u>	<u>Charge</u>
1/30	5	105	300	306	6
				322	6
				285	6
				317	1
				324	3
1/30	5	155	300	402	4 (Air)
1/30	7	105	300	358	5
				232	7
				312	5
				221	7
					7
1/31	6	105	380	282	3
1/31	9 (Unk)	105	347	371	6
				303	5
				387	4
				416	3
				422	3
				421	2
2/2	4 (Unk)	155 4.2 in.	335	406	2
				900	20
				375	1
				266	1
2/6	10	105	116	462	4
				536	4
2/7	11 (Unk)	105	111	456	4
				536	4
2/8	12 (Unk)	105	263 90 106	566	4
				525	4
				449	4
2/14	15	175	250	541	3
2/15	16	175	208	560	3
2/21	15A	8 in.	+24	546	7
			+24	618	6
2/22	16A (Unk)	8 in.	+25	671	7
			+23	518	7

<u>Date (1973)</u>	<u>Test</u>	<u>Weapon</u>	<u>FP</u>	<u>QE (mils)</u>	<u>Charge</u>
2/27	13	155 Btry	710	416	6
				458	6
				428	6
2/28	13A (Unk)	155 Btry	705	305	6
				349	6
				331	6
3/6	18	4.2	90	900	19 4/8
				900	19 2/8
		81	90	1004	7
				1020	7
3/6	17	175	30	680	2

ANNEX II. WEAPON LOCATION TEST SUMMARY

Test	Radar	Location	Range	Weapon (km)	Test	Location	Error (M)	Percent	Ratio	Blip Scan	Remarks
8	Elgin	155	10.7	Confirm	100	60					Air Burst Observation
18-2	Gate House	4.2	5.4	Confirm	180						Short Range - Heavy Clutter
18-4	Gate House	81	5.4	Confirm	75						Short Range - Heavy Clutter
13-1	POA-2	155Btry12.5	Confirm	280	70						0 dB Attn. in RX
13-2	POA-2	155Btry12.5	Confirm	360							12 dB Attn. in RX
13-3	POA-2	155Btry12.5	Confirm	80	70						6 dB Attn. in RX
13A-1	POA-2	155Btry11.1	Locate	280	80						{ Significant Return when
13A-2	POA-2	155Btry11.1	Locate	300	80						Contrasted with Single
13A-3	POA-2	155Btry11.1	Locate	280	80						Piece 155 mm Howitzer
13(Reg.)	POA-2	155	12.5	Unscheduled	80	70					Unofficial Observation
15A-1	POA-2	8 in.	17.4	Confirm	225	35					
15A-2	POA-2	8 in.	17.4	Confirm	225	25					
16A-1	POA-2	8 in.	18.1	Locate	75	20					Heavy Snow Falling - 1000M Vis.
16A-2	POA-2	8 in.	16.3	Locate	80	50					Heavy Snow Falling - 1000M Vis.
10-1	FP181	105	9.8	Confirm	200	95					No Masking
10-2	FP181	105	9.8	Confirm	270	60					No Masking
11-1	FP181	105	9.3	Locate	100	85					Wind Gust 50 knots, Ice, Rain
11-2	FP181	105	9.3	Locate	150	40					Wind Gust 50 knots, Ice, Rain
12-1	FP181	105	10.7	Locate	290	70					Wind Gust 50 knots, Ice, Rain
12-2	FP181	105	9.6	Locate	220	35					Wind Gust 50 knots, Ice, Rain
12-3	FP181	105	8.5	Locate	220	10					Wind Gust 50 knots, Ice, Rain
4-1	Elgin	155	13.7	Locate	470						Weapon Identification Test
4-2	Elgin	4.2	13.7	Locate	640						Weapon Identification Test
4-3	Elgin	105	13.7	Locate	470						Weapon Identification Test
4-4	Elgin	175	13.7	Locate	360						Weapon Identification Test
9-1	Elgin	105	11.3	Locate	850	70					Other Weapons Firing in Area
9-2	Elgin	105	10.2	Locate	710	80					Other Weapons Firing in Area
9-3	Elgin	105	8.4	Locate	250	85					Other Weapons Firing in Area
9-4	Elgin	105	9.0	Locate	760	70					Other Weapons Firing in Area
9-5	Elgin	105	8.2	Locate	290	80					Storm Front in Area
9-6	Elgin	105	7.3	Locate	200	100					Storm Front in Area

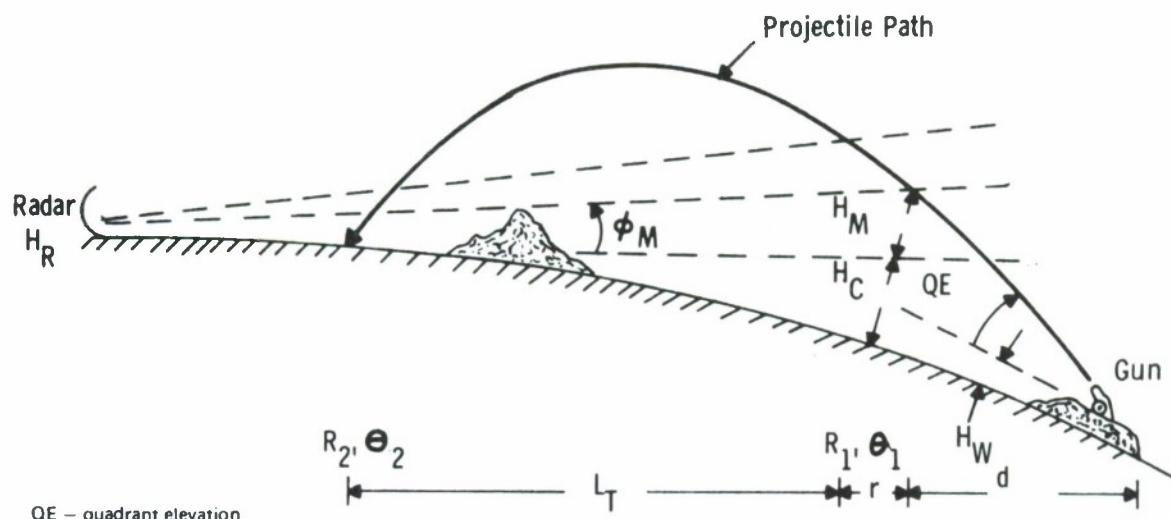
Test	Radar Location	Range	Weapon (km)	Test	Blip Scan		Remarks
					Location Error (M)	Percent	
5-1	Elgin	105	10.7	Confirm	840	75	Resection Error < 100M
5-2	Elgin	105	10.7	Confirm	950	80	Resection Error < 100M
5-3	Elgin	105	10.7	Confirm	440	60	Resection Error < 100M
5-4	Elgin	105	10.7	Confirm	50	60	Resection Error < 100M
7-1	Elgin	105	10.7	Confirm	50	60	Other Weapons Firing in Area
7-2	Elgin	105	10.7	Confirm	750	75	Other Weapons Firing in Area
7-3	Elgin	105	10.7	Confirm	50	60	Other Weapons Firing in Area
7-4	Elgin	105	10.7	Confirm	50	65	Other Weapons Firing in Area
2-3	Elgin	4.2	8.4	Confirm	100	100	Heavy Point Clutter
2A-1	Elgin	4.2	13.4	Confirm	880	60	Clutter Free Area
2A-2	Elgin	4.2	13.4	Confirm	520	65	Clutter Free Area
2A-3	Elgin	4.2	13.4	Confirm	740	63	Clutter Free Area
2A-4	Elgin	4.2	12.4	Confirm	550	60	Clutter Free Area
2A-5	Elgin	4.2	13.4	Confirm	100	50	Clutter Free Area
2B-1	Elgin	4.2	21.9	Confirm	400	400	Weapon Near Signal Mountain
2B-2	Elgin	4.2	21.9	Confirm	500	500	Weapon Near Signal Mountain
2B-3	Elgin	4.2	21.9	Confirm	180	60	Weapon Near Signal Mountain
2B-4	Elgin	4.2	21.9	Confirm	1060	1060	Weapon Near Signal Mountain
2B-5	Elgin	4.2	21.9	Confirm	650	650	Weapon Near Signal Mountain
3B-5	Elgin	4.2	23.4	Locate	1300	100	Trajectory Over Signal Mountain
3-1	Elgin	4.2	13.6	Locate	410	100	High Blip Scan Ratio
3-2	Elgin	4.2	13.6	Locate	410	100	High Blip Scan Ratio
3-3	Elgin	4.2	13.6	Locate	410	65	High Blip Scan Ratio
3-4	Elgin	4.2	13.6	Locate	900	50	High Blip Scan Ratio
3-5	Elgin	4.2	13.6	Locate	150	85	High Blip Scan Ratio
3A-1	Elgin	4.2	8.2	Locate	710	60	Large Point Clutter
3A-2	Elgin	4.2	8.2	Locate	640	30	Large Point Clutter
3A-3	Elgin	4.2	8.2	Locate	540	30	Large Point Clutter
3A-5	Elgin	4.2	8.2	Locate	750	50	Large Point Clutter

UNSUCCESSFUL LOCATION TEST SUMMARY

<u>Test</u>	<u>Radar Location</u>	<u>Weapon</u>	<u>Range (km)</u>	<u>Probable Cause</u>
14, 15, 16	POA-2	175	31.5	*Target Aspect-Low Radar Cross Section
18-1	Gate House	4.2	5.4	CPACS Capture - Severe Clutter
18-3	Gate House	81	5.4	CPACS Capture - Severe Clutter
5-5	Elgin	105	10.7	Tangential Trajectory - Low Radial Vel.
2-1	Elgin	4.2	8.4	CPACS Capture - Point Clutter
2-2	Elgin	4.2	8.4	CPACS Capture - Point Clutter
2-4	Elgin	4.2	8.4	CPACS Capture - Point Clutter
2-5	Elgin	4.2	8.4	CPACS Capture - Point Clutter
3B-1	Elgin	4.2	23.4	Trajectory Over Signal Mountain
3B-2	Elgin	4.2	23.4	Trajectory Over Signal Mountain
3B-3	Elgin	4.2	23.4	Trajectory Over Signal Mountain
3B-4	Elgin	4.2	23.4	Trajectory Over Signal Mountain
3A-4	Elgin	4.2	8.2	Large Point Clutter in Vicinity

*155 mm Howitzer observed and located at 27 km during these tests.

Weapon Locating Technique Using TPS-61 ()



QE - quadrant elevation

R_1, θ_1 - range and azimuth of projectile at first detection

R_2, θ_2 - range and azimuth of projectile at last detection

L_T - radar observed projectile flight path length

d - distance traveled by projectile before it enters radar field of view

r - distance traveled by projectile after it enters radar field of view and before it is detected

H_M - height of mesh at detection range

H_C - height correction for earth's curvature

H_R - height of radar

H_W - height of weapon

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Figure 20. Physical Interpretation of Weapon Locating Techniques

ANNEX III. COMPUTER CORRECTIONS MADE TO RAW RADAR DATA

A detailed description of the weapon-location technique will serve to show how radar data was processed in the computer to locate weapons. First the methodology will be presented, and then the actual procedure, including the data inputs to the computer, will be listed.

Step 1 - The observed radar data ($R_1, \theta_1, R_2, \theta_2$) are used to calculate L_T (the radar-observed projectile path length) using the law of cosines. The physical significance of these parameters is shown in figure 20, and the PPI geometry is shown on figure 21.

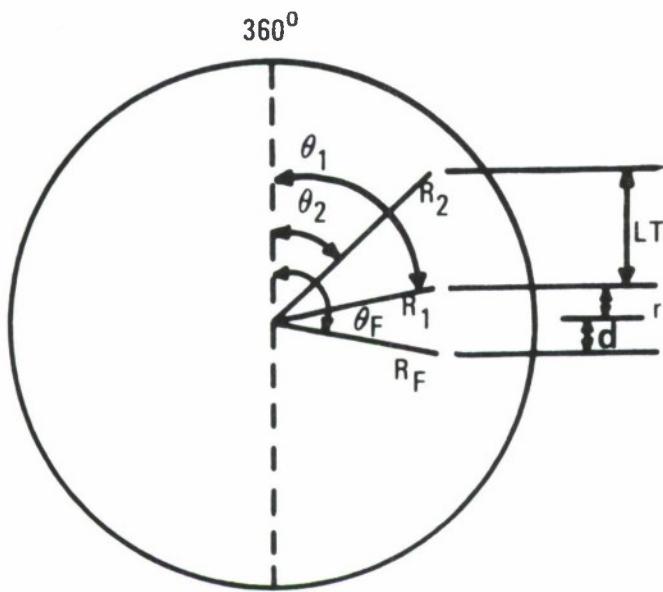
Step 2 - The next step is to find H , the height of the projectile above the weapon, when the projectile first enters the field of view of the radar. This height, H , is composed of four components

$$H = H_M + H_R + H_C - H_\omega$$

These components are obtained in the following manner:

H_M is the height measured by the radar. Although the AN/TPS-61() is a 2D radar, height information can be obtained by measuring masking angles as a function of azimuth. The masking angles, ϕ_M in figure 20, are determined optically during radar installation; and a table of masking angle versus azimuth is prepared. For example, at an azimuth of θ_1 , the masking angle is ϕ_1 , and

$$HM_1 = R_1 \sin \phi_1$$



- R_1, θ_1 - RANGE AND AZIMUTH OF PROJECTILE AT FIRST DETECTION
- R_2, θ_2 - RANGE AND AZIMUTH OF PROJECTILE AT LAST DETECTION
- LT - RADAR OBSERVED PROJECTILE FLIGHT PATH LENGTH
- R_F, θ_F - FINAL RANGE AND AZIMUTH TO WEAPON

73-0640-VA-24

Figure 21. PPI Geometry of Weapon Locating Technique

Then H_M is the height of the projectile with respect to the local horizontal. To obtain a height with respect to the weapon, the effects of earth curvature, H_C , has been added. The last term, H_ω , is the height of the weapon above ground level. It is subtracted from the height of the radar H_R . An estimate of H_ω is made from a topographical map having made a gross estimate of weapon position.

Step 3 - Knowing H , then d on figure 20 can be calculated, if QE is known, from $d = H/\tan(QE)$. The variable d is the distance traveled by the projectile before it enters the field of view of the radar. The QE is found by using the L_T found in step one, and the prepared firing chart shown on figure 22. The responsibility for determination of weapon class (mortar, howitzer, long range gun) is with the radar. This is determined by visual observation of the display from separation between scan intervals and the length of track. Within each class it is reasonable to assume that the type of weapon will be known from intelligence reports. To differentiate between class and type, the US Army's weapons will be illustrated.

<u>Weapon Class</u> <u>(From Radar Observations)</u>	<u>Weapon Type</u> <u>(From Intelligence Reports)</u>
Mortars (MV \approx 200 m/s)	81 mm
Howitzers (MV \approx 400 m/s)	4.2 inch
	8 inch
	105 mm
	155 mm
Guns (MV \approx 900 m/s)	175 mm

For each of these weapon types, a firing chart similar to figure 22 has been prepared.

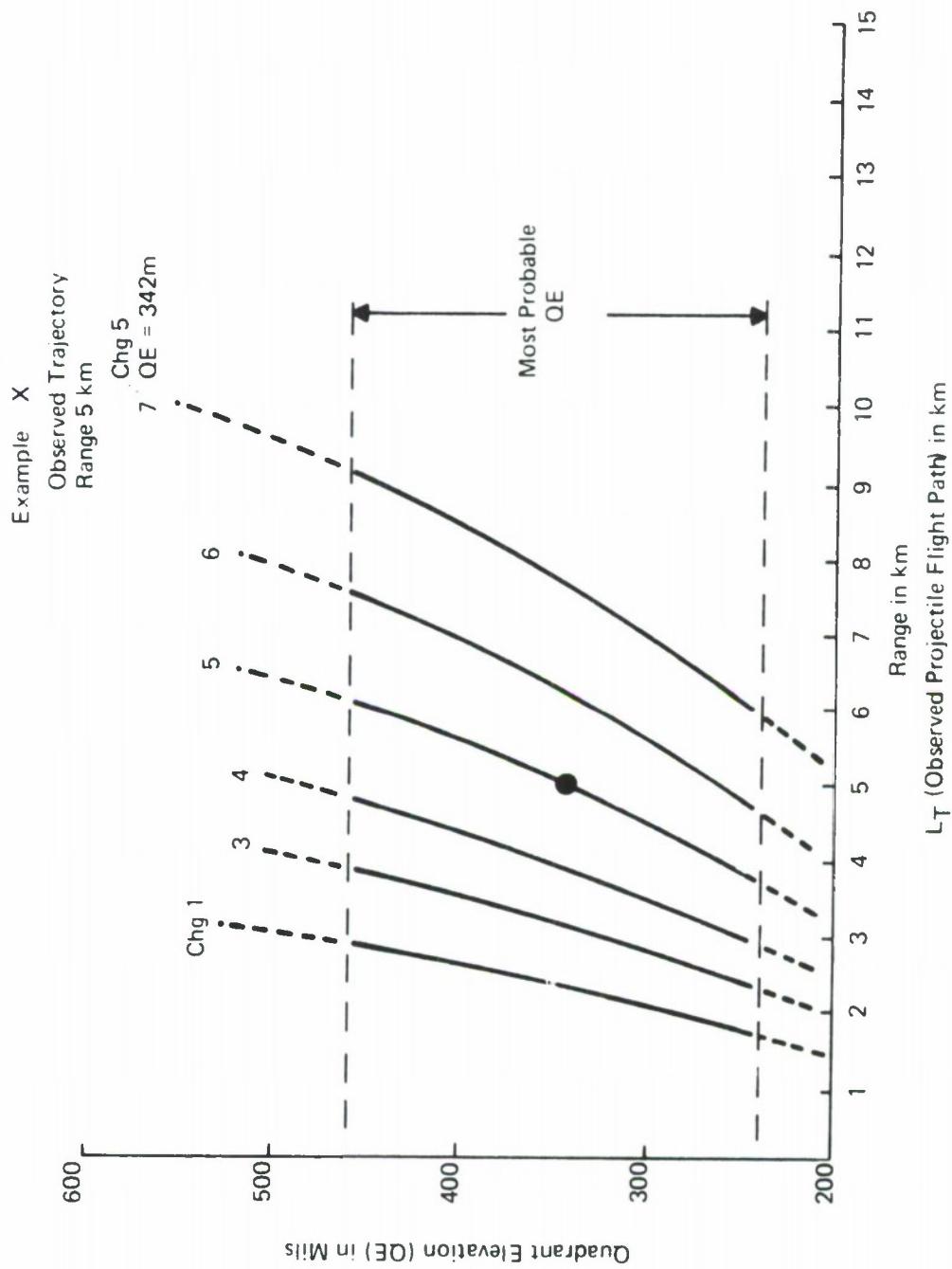


Figure 22. Estimation of QE and Charge

On figure 22 is shown a typical example. For an $L_T = 5$ km, then the most probable charge used was number five; for a number five charge, the QE is 342 mils. The distance d can then be found.

Step 4 - As mentioned in step 3, d is the horizontal distance that the projectile travels before it enters the field of view of the radar. However, when the radar is in the scanning mode with a scan time of 4 seconds, the radar, on an average, will observe the projectile 2 seconds after it enters the field of view. Rather than traveling a horizontal distance d before radar observation, the projectile will have traveled a distance $r + d$. Therefore, r (on figure 20) can be determined from

$$r = \frac{VT}{2} \left[1 - (0.01)^{\frac{1}{N}} \right] \cos(QE)$$

Where V is the initial velocity of the projectile

T is the antenna scan time = 4 seconds

N is the number of rounds observed

QE is the quadrant elevation.

The relationship shows that as N (the number of rounds observed) gets large, r goes to zero.

Also, when the radar is operated in the searchlight mode, r goes to zero, because the radar observes the projectile as soon as it enters the field of view - i.e., $T = 0$.

All parameters in the relationship for r are known - QE was determined from figure 22, and the charge number determines the initial velocity, V .

Step 5 - Having found d and r , these two terms can be added to L_T on figure 21 in order to find the location of the weapon. The range and azimuth to the weapon are then found by the law of cosines.

Step 6 - Refinements in weapon location can be made by transferring the estimated position to a topographical map of the area. This will show the most probable location of a weapon emplacement near the estimated point.

Step 7 - An iteration of the above procedure is used to refine the data. In general, one iteration is sufficient. The iteration refines previous estimates. For example, the first estimate of QE from figure 22 assumed that the total projectile flight path was L_T . In reality, it was $L_T + r + d$. A further refinement can also be made in the estimate of H_ω in step 2, since the weapon position is known more accurately. In summary, then, the weapon location sequence is the following, using the computer to perform all calculations. All computer entries, computations, table lookups, and map plotting were performed in less than 5 minutes.

WEAPON LOCATION SEQUENCE

Step 1 - Enter Radar Data to Computer

R_1, θ_1	Observed coordinates of earliest reported scan (closest to weapon)
R_2, θ_2	Observed coordinates of last reported scan (closest to impact)
N	Number of rounds observed
T	Scan period in seconds (typically 4)
H_R	Height of radar
H_ω	Height of weapon from R_1, θ_1 and contour map

Step 2 - Computer Calculates Observed Flight Path Length

$$L_T = \left[R_1^2 + R_2^2 - 2R_1 R_2 \cos(\theta_1 - \theta_2) \right]^{1/2}$$

Computer Calculates Weapon Height Difference at Earliest Detection

$$H = H_C + H_M + H_R - H_w$$

Step 3 - Select QE and V from Firing Charts as a Function of Weapon and L_T

Step 4 - Computer Calculates Distance Traveled Before First Possible Detection

$$d = H/\tan(QE)$$

Step 5 - Computer Calculates Distance Traveled from First Possible Detection to Radar Observed Detection

$$r = \frac{V_T}{2} \left[1 - (0.01) \right]^{-1/N} \cos(QE) \quad (\text{Scan Mode})$$

$$r = 0 \quad (T = 0 \text{ if in searchlighting mode})$$

Step 6 - Computer Range and Azimuth to Weapon

$$R_F = \left[R_1^2 + (r+d)^2 + 2R_1(r+d) \frac{R_1 - R_2 \cos(\theta_1 - \theta_2)}{L_T} \right]^{1/2}$$

$$\theta_F = \theta_1 + \tan^{-1} \left[\frac{(r+d) \frac{(R_2 \sin(\theta_1 - \theta_2))}{L_T}}{R_1 + (r+d) \frac{(R_1 - R_2 \cos(\theta_1 - \theta_2))}{L_T}} \right]$$

Step 7 - Repeat steps 2 through 6 with Better Estimate of QE and H_w

Step 8 - Report Final Range and Azimuth to Weapon

To summarize, the origin of the estimates is:

<u>Maps</u>	<u>Tables</u>	<u>Radar</u>	<u>Computer</u>
H_w	ϕ_M	T	H_M
H_R	QE (from L_T)	R_1, θ_1	H_C
	V (from L_T)	R_2, θ_2	H
			d
			L_T
			R_F
			θ_F

**ANNEX IV. ADDITIONAL ASR TESTS
FORT SILL, OKLAHOMA**

ASR Flight Test

Tangential Run from 5.3 NM NW to 6.3 NM NE (80 Knots)

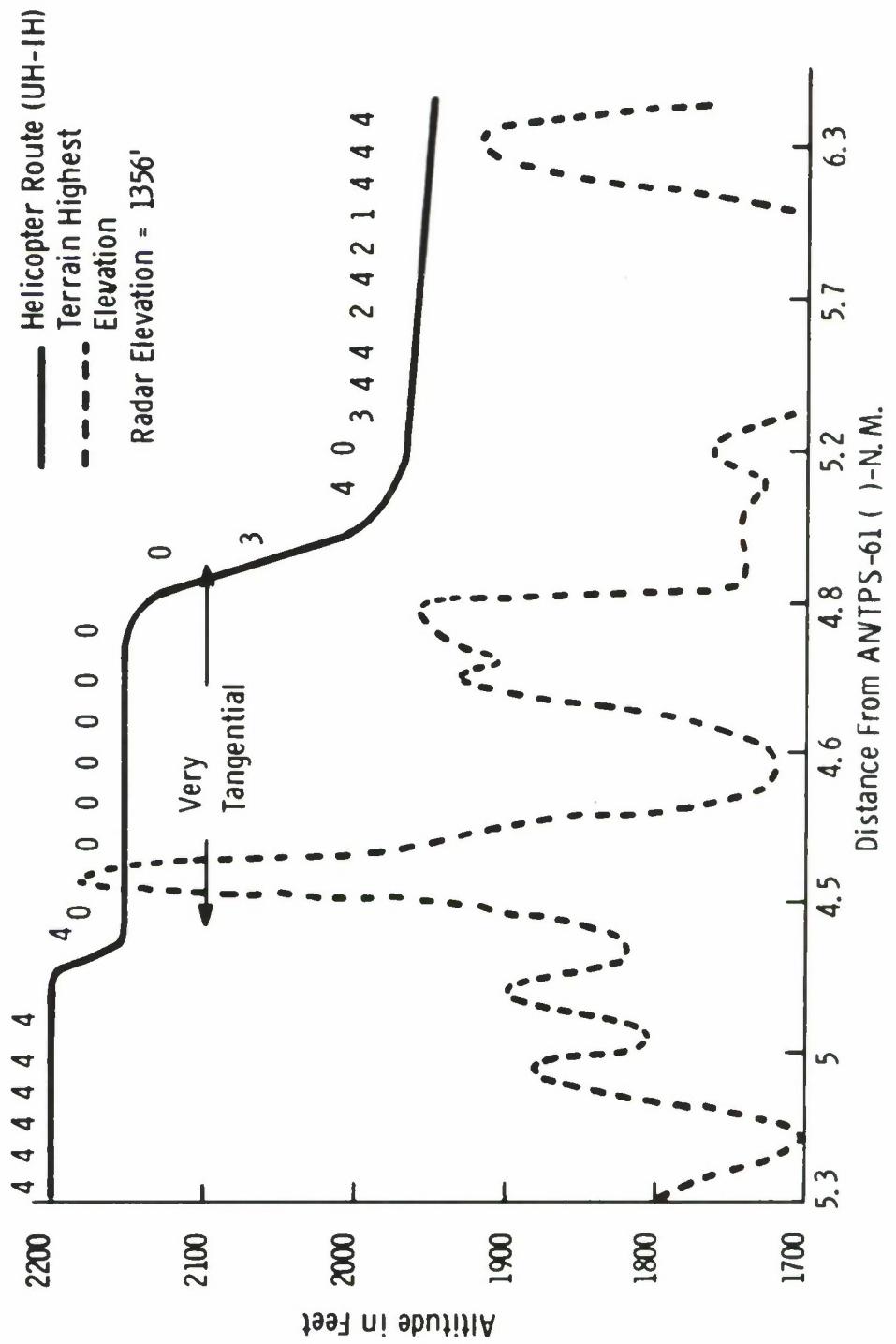


Figure 23. ASR Flight Test Data

ASR Flight Test

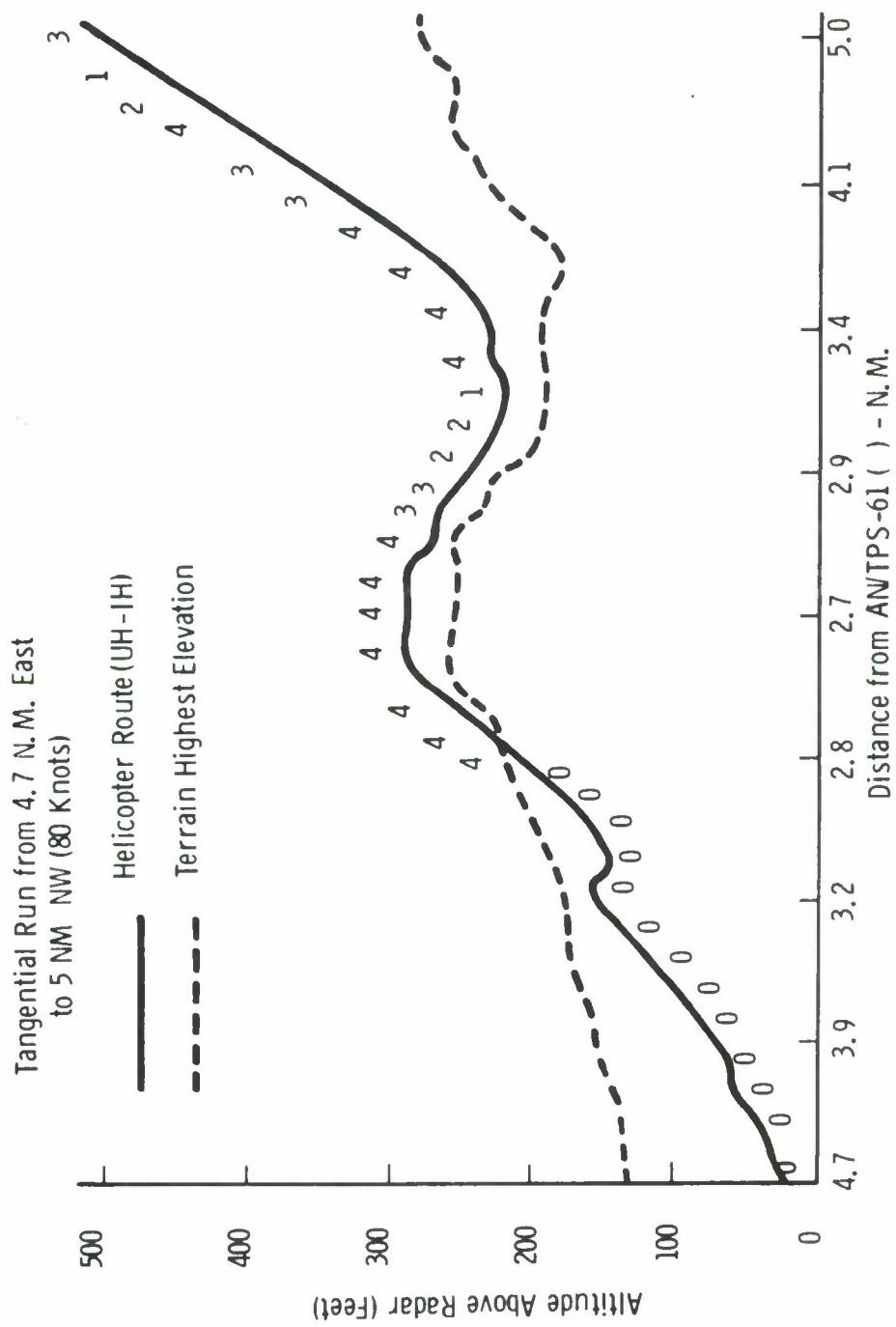


Figure 24. ASR Flight Test Data

ANNEX V. FORT SILL TEST INFORMATION SHEETS (TIS)

The Test Information Sheet (TIS) is a concise one-page description of each test. It includes such information as weapon data, radar status/mode, test description, weather conditions, and display data. Final raw radar data was recorded under the heading B SCOPE DATA, and in most circumstances is the best data for approximately the first five rounds. These sheets were filled in the same day as the conduct of mission and presented to the Land Warfare Laboratory representative the following day. The enclosed sheets are a reproduction of the originals except for typed entries rather than handwritten.

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No	2
Date	1/23/73
Weather	Clear
Site	Elgin Ridge
*WPN	4.2" Mortar
*WPN Location	(if known)
Az(Hills)	Tp497
RNG(KM)	1.52 NM-195.6
Site Altitude(M)	391M

*GUN DATA

Charge	See below
Q.E. (Mils)	900
AZ (Mils)	

TEST DESCRIPTION

To verify 4.2" mortar location

RADAR MODE	26
Z (us)	On
STC(on/off)	On
N.O.B. (Deg)	+3
PPI Scale (NM)	7.5
Range(M)	

MISSION REMARKS	Unable to observe 1st part of track consistently due to large point clutter at FP (affected CPACS Mode)
-----------------	---

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA RNG AZ	SCOPE DATA RNG AZ	SCALE	WPN/TGT FIND	REMARKS
1-5 (Ch 17)	SCN	3.95 NM	197°	6 milx20°	Tgt	B/S data was marginal and only useful for cueing, impact from scope shown at left.
6-10 Charge (12 6/8)	SCN	4.1 NM	197.1°	6 milx20°	Tgt.	See note above.

*Data to be filled in after mission when required per test.

73-0640-VB-27

MISSION PARTICULARS

TEST INFORMATION SHEET (RADAR DATA)

GUN DATA		TEST DESCRIPTION To verify 4.2" mortar location	
Charge	See below		
Q.E. (Mils)	900		
AZ (Mils)			
RADAR MODE		RADAR STATUS	
Z (us)	4	High swept, CFA	
STC (on/off)	On		
N.O.B. (Deg)	+3 dB		
PPI Scale (NM)	7.5 NM	MISSION REMARKS	
Range(M)		Backup mode used (4 us) with STC due to large pt. clutter at FP.	

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA		B SCOPE DATA		WPN/TGT FLND	REMARKS
		RNG	AZ	RNG	AZ		
11-15	SCN	4.5 NM	195°	6 NMx20°		WPN TGT	Observed 3 hits & impact on scope (error = 100M)
"	"						
(Ch 19-2/8)							
16-20	SCN	2.95 NM	196.6°			TGT	B/S marginal & useable for cueing. Impact from scope shown at left.
(Ch 13-2/8)							
20-25	SCN	3.1 NM	203.6°			TGT	B/S marginal and useable for cueing - All impacts observed.
(Ch 19)							

*Data to be filled in after mission when required per test.

73-0640-VB-28

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS		*GUN DATA		TEST DESCRIPTION		Observed numerous 105 mm Howitzer rounds	
Mission No.	Tgts. of oppor.	Charge	Q, E (Mils)				
Date	1/23/73	AZ (Mils)	Unk				
Weather	Clear	RADAR MODE	Z (us)	26			
Site	Eglin Ridge		STC (on/off)	On			
WPN	105 mm Howitzer		N.O.B. (Deg)	+3db			
WPN Location (if known)			PPI Scale (NM)	15			
Az (Mils)			Range (M)				
RNG (NM)							
Site Altitude (M)							

MISSION DATA		PPI DATA		B SCOPE DATA		WPN/TGT FIND		REMARKS	
RND NO.	FIND MODE	RNG	AZ	RNG	AZ	SCALE			
-	SCN			7.75	195°	6 x 20	WPN		100% B/S. from daily firing
-	SCN			6.5	194°	"	TGT		sched. FP=510 (student prob.
-	SCN			8.1	196°	"	WPN		GOF152) at 7.9 NM 196°
									100% B/S from daily firing
									sched. FP=509 (student prob.
									GOF152) at observed range.

*Data to be filled in after mission when required per test.

73-0640-VB-29

MISSION PARTICULARS

TEST INFORMATION SHEET (RADAR DATA)

TEST DESCRIPTION To verify 4.2" mortar location

MISSION PARTICULARS	
Mission No	2A
Date	1/23/73
Weather	Clear
Site	Elgin Ridge
#AFN	4.2" Mortar
Location	(if known)
Az (Mil)	RP 351
RNG (KM)	(7.2 NM at 185°)
Site Altitude (M)	391

INTRODUCTION

MISSION	MISSION	MISSION	MISSION	MISSION	MISSION	MISSION	MISSION
MISSION	MISSION	MISSION	MISSION	MISSION	MISSION	MISSION	MISSION
RND NO.	FIND MODE SCN/SCH	PPI DATA RNG AZ	RNG	B SCOPE DATA AZ	SCALE	WPN/TGT FIND	REMARKS
1-5 "	SCN "		6.9 NM 5.7 NM	187.1° 190°	6m1x20° "	WPN TGT	Observed 5 rounds. Real time radar est. shown at left. (Act. WPN Location = 7.2 NM at 185°) (Mortar fired at impact pt. 388) Observed 60% B/S on scope.
(Ch 17)							
6-10 " (Charge 20-4/8)	SCN " "		7.1 NM 6.5 NM	187° 190°	6x20 "	WPN TGT	Observed 5 rounds. Real time radar est. shown at left. Mortar fired at impact pt. 386). Observed 65% B/S on scope.

*Data to be filled in after mission when required per test.

73-06640-VB-30

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No. 2A
 Date 1/23/73
 Weather Clear
 Site Elgin Ridge
 *WPN 6.2" Mortar
 Location (if known)
 Az(Mils) FP351
 RNG(KM) (7.2 KM at 185°)
 Site Altitude(N) 391M

*GUN DATA

Charge See below
 Q.E. (Mils) 900
 AZ (Mils) _____
 RADAR MODE 26
 Z (us) _____
 STC (on/off) Off
 N.O.B. (Deg) +3 dB
 PPI Scale (NM) 15
 Range(M) _____

TEST DESCRIPTION To verify 4.2" mortar location

Note: All known fire and impact points were treated as unknown until est. were made.

RADAR STATUS High swept, CFA mode, B-scope start sector = 180°

MISSION REMARKS Computer runs were made for 1-5, 11-15, and 21-25 and are shown on separate sheets. Rate of fire 30 sec. between rds.

MISSION DATA

RND NO.	FIND MODE SCN/SCR	PPI DATA RNG AZ	B SCOPE DATA		WPN/TGT FIND	REMARKS
			RNG	AZ	SCALE	
11-15	SCN		6.9 NM	187°	6NM 20 °	WPN TGT
"	"		5.9 NM	190.5°	"	Observed 5 rds. Real time radar est. shown at left. Mortar fired at impact pt. 395.
(Ch 15-4/8)						Observed 63% B/S on scope
16-20	SCN		6.9 NM	185°	6 20 20	WPN TGT
"	"		6.3 NM	189.5°	"	Observed 5 rds. Real time radar est. shown at left. Mortar fired at impact pt. 349.
(Ch 19)						Observed 60% B/S on scope.

*Data to be filled in after mission when required per test.

73-0640-VB-31

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No.	2A	Charge	See below
Date	17/3/73	Q.E. (Mils)	900
Weather	Clear	AZ (Mils)	
Site	Elgin Ridge	RADAR MODE	
WTN	4.2" Mortar	Z (us)	26
WPN Location (if known)		STC (on/off)	Off
Az (Mils)	FP351	N.O.B. (Deg)	+3
RNG (NM)	(7.2 NM at 185°)	PPI Scale (NM)	15
Site Altitude (M)	391M	Range (M)	

TEST DESCRIPTION To verify 4.2" mortar location

Note all known fire and impact pt. were treated as unknown until est. were made.

RADAR STATUS	High speed. CFA mode. B-scope start of sector =
STC (on/off)	180° and 3.5 NM.
N.O.B. (Deg)	
PPI Scale (NM)	Computer runs were made for 1-5, 11-15, and
RNG (M)	21-25 and are shown on separate sheets. Rounds fired at 30 sec. interval.

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA RNG	RNG	B SCOPE DATA AZ	SCALE	WPN/TGT FIND	REMARKS
21-25 (Ch 17-4/2)	SCN		7.2 NM	185°	6NMx20°	WPN	Observed 5 rds. Real time radar est. shown at left. (Act. Wpn location = FP351 7.2NM at 185°) (Mortar fired at impact pt. 327.) Observed 51% B/S on scope.

*Data to be filled in after mission when required per test.

73-0640-VB-32

TEST INFORMATION SHEET (RADAR DATA).

MISSION PARTICULARS		* GUN DATA	
Mission No.	2B	Charge	
Date	1/24/73	Q.E. (Mils)	900
Weather	Clear	AZ (Mils)	
Site	Elgin Ridge	RADAR MODE	
*WPN	4.2" Mortar	Z (us)	26
*NPN	Location (known)	STC (on/off)	On
Az(Mils)	#174	N.O.B. (Deg)	+3 dB
RNG(KM)	DAILY HILL	PPI Scale (NM)	15
Site Altitude(M)	391M	Range(M)	

卷之三

TEST DISCRETION 10 verily 4.2" Mortar Location in clutter at long range.

RADAR STATUS	High swept, CFA mode.
MISSION REMARKS	B-scope sector set for 7 M, 230° start. B/S data averaged 55% for all rounds

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA RNG	PPI DATA AZ	RNG	AZ	SCOPE DATA SCALE	WPN/TGT FIND	REMARKS
1-5 (Ch 14-4/8)	SCN			11.5 NM	237°	6x20°	WPN	WPN and TGT impact points composite of
	"			10.45	240°	"	TGT	5 rds. See computer reduction sheets for refined answer.
6-10 (Ch 16)	SCN			11.5	237°	6x20°	WPN	See above
	"			10.4	241°	"	TGT	Poor B/S
11-15 (Ch 17-4/8)	SCN			11.8	236°	6x20°	WPN	See above
	"			10.75	243°	"	TGT	60% B/S

*Data to be filled in after mission when required per test.

73-0640-VB-33

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

GUN DATA	
Charge	
Q.E. (Mils)	900
AZ (Mils)	
RADAR MODE	
Z (us)	26
STC (on/off)	On
N.O.B. (Deg)	+3
PPI Scale (NM)	15
Range(M)	
Site Altitude(M)	391

TEST DESCRIPTION To verify 4.2" Mortar in clutter at long range.

Mission No.	2B	Charge	
Date	1/24/73	Q.E. (Mils)	900
Weather	Clear	AZ (Mils)	
Site	Elgin Ridge	RADAR MODE	
RTN	4.2" Mortar	Z (us)	26
RTN Location (if known)	Hill 1/4	STC (on/off)	On
AZ(Mils)		N.O.B. (Deg)	+3
RNG(KM)	Day Hill	PPI Scale (NM)	15
Site Altitude(M)	391	Range(M)	

MISSION DATA

RND NO.	PPI DATA		B SCOPE DATA		WPN/TGT FIND	REMARKS
	FIND MODE	PNG	RNG	AZ	SCALE	
16-20	SCN		11.2	238°	6x20°	
"	"		10.45	242°	"	
(Ch 19-4/8)						Missed 1st part of track.
21-25	SCN		11.35	237°	6x20°	
(Ch 19)	"		10.2	241°	"	
						WPN and tgt. impact pts. composite of 5 rds. See computer reduction for refined data.

*Data to be filled in after mission when required per test.

73-0640-VB-34

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

* GUN DATA	
Charge	Unit
Q. E. (Mils)	900
AZ (Mils)	Unk
RADAR MODE	
Z (us)	26
STC (on/off)	On
N.O.B. (Deg)	+3
PPI Scale (NM)	15
Range(M)	

TEST DESCRIPTION To locate 4.2" mortar at long range in clutter

(w/o apriori knowledge)

Mission No.	3
Date	1/24/73
Weather	Clear
Site	Elgin Ridge
*WPN Location (if known)	4.2" Mortar
AZ (Mils)	Unk
RNG (KM)	Unk
Site Altitude(M)	391M

in same general area all adequate for Wpn location.

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA RNG AZ	B SCOPE DATA			WPN/TGT FIND	REMARKS
			RNG	AZ	SCALE		
1-25	SCN		10.55	231.0	6x20	WPN	Observed in sequences 3,4,5 105 MM How from FP 70 (300M error) B.S.R. = 90%
			13.0	248	6x20	WPN	Observed in sequences 1,2 and between sequences - Probable fire from 105MM How at FP628 (adequate for cueing) B.S.R. = 80%
			12.75	243	6x20	WPN	Observed in sequence 2,3 How. fire (FP unknown) (Adequate for cueing) B.S.R. = 80%
			11.75	237.4	6x20	WPN	Observed during last sequence-Declared 4.2" because of contrast with above weapons not deemed adequate for cueing or location. Marginal B.S.R. 4.2" declared 4620 3545. Computer not used due to inadequate number of hits.

*Data to be filled in after mission when required per test.

* 4.2" Located at F.P. 169 (per T. Olon) after mission report error 1.3 KM.

73-0840-VB-35

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No. 3
 Date 1/26/73
 Weather Clear
 Site Eqlin Ridge (445)
 WPN 4.2" Mortar
 WPN Location (if known)
 Az(Mils) Unk
 RNG(KM) 10
 Site Altitude(M) 391

*GUN DATA

Charge
 Q.E. (Mils) 900
 Az (Mils)
 RADAR MODE
 Z (us) 26
 STC (on/off) On
 N.O.B. (Deg) +3db
 PPI Scale (NM) 10
 Range(M)

TEST DESCRIPTION

To locate 4.2" mortar at moderate range
 RADAR STATUS
 High swept, CFA B-Scope set at 2 NM/175°
 MISSION REMARKS
 Attached computer summary sheets give
 computer location. Clutter was effectively cancelled
 in general fire area.

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA RNG AZ	RNG (NM)	B SCOPE DATA AZ	SCALE	WPN/TGT FIND	WPN/TGT	REMARKS
1-5	SCN		7.55 6.5	181° 187°	6°x20° "	WPN TGT	TGT	B/S Ratio = 100%
6-10	SCN		7.55 6.5	181° 190°	"	WPN TGT	TGT	B/S = 100%
11-15	SCN		7.55 6.05	181° 193°	"	WPN TGT	TGT	B/S = 65%
16-20	SCN		6.95 6.2	184° 189°	"	WPN TGT	TGT	B/S = 50%
21-25	SCN		7.4 6.2	181° 185.5°	"	WPN TGT	TGT	B/S = 85%

*Data to be filled in after mission when required per test.

Actual WPN Location = FP524 (given after test)

73-0640-VB-36

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No. 3A
 Date 1/26/73
 Weather Clear
 Site Eqlin Ridge (445)
 "WPN 4.2" Mortar
 "MTN Location (if known)
 Az (Mils) Unk
 RNG (KM) Unk
 Site Altitude(M) 391 m

TEST DESCRIPTION To locate 4.2" Mortar at short range

<u>*GUN DATA</u>		<u>RADAR STATUS</u>		<u>MISSION REMARKS</u>	
Charge		Hi swept,	CFA - Rds	21-25 used	4 us p.w.
Q.E (Mils)	<u>900</u>				
AZ (Mils)					
<u>RADAR MODE*</u>					
Z (us)	<u>26</u>				
STC (on/off)		On			
N.O.B. (Deg)	<u>+3db</u>				
PPI Scale (NM)	<u>10NM</u>				
Range(M)					

rounds were observed in firing area. Lge. pt. clutter
 - to-left-of-fp.

MISSION DATA

RND NO.	FIND MODE	PPI DATA		B SCOPE DATA 180°		WPN/TGT FIND	REMARKS
		RNG	AZ	SCALE	SCALE		
1-5	SCN	4.7	191°	6	20°	WPN	60% B/S
		3.2	196°	"	"	TGT	
6-10	SCN	4.4	192°	"	"	WPN	30% B/S
		3.5	193°	"	"	TGT	
11-15	SCN	4.55	191°	"	"	WPN	30% B/S
		3.8	197°	"	"	TGT	
16-20	SCN						Not valid for scoring
21-25	SCN	4.55	192°	"	"	WPN	
		2.45	192.5°	"	"	TGT	

*Data to be filled in after mission when required per test.

73-0640-VB-37

Actual wpn location given as 200 yds east of FP415.

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No. 1/26/73
 Date 1/26/73
 Weather Clear
 Site Eglin Ridge
 WPN 105 mm Howitzer
 Location (if known) Az(Mils) Calculated to be
RNG(KM) FP509 or 510
Site Altitude(M) 391

*GUN DATA

Charge "
 Q.E. (Mils)
 Az (Mils)
RADAR MODE
Z (us) 26
STC (on/off) On
N.O.B. (Deg) 3 db
PPI Scale (NM) 10
Range(M) _____

TEST DESCRIPTION

Tracked tgts of opportunity 105 mm
 Howitzer Probable fire point = 509 or 510 located at
 795 NM 195° (daily schedule showed 105's firing at
 this point student prob. (GOF 152 (27 Jan 73)
RADAR STATUS High sweep

MISSION REMARKS

The following data on 105 mm Howitzers
 (tgts of opportunity) was recorded during scoring of
 mission 3A.

MISSION DATA

RNG NO.	FIND MODE	PPI DATA	B SCORE DATA			WPN/TGT	REMARKS
			RNG	AZ	SCALE	FIND	
SCN			7.55	195°	6 x 20°	WPN	100% B/S observed during
SCN			5.75	198°	"	TGT	series 4 (rds 16-20) of test 3A Noted helicopter in area
SCN			7.4	194°	"		100% B/S observed during 30
SCN			5.75	198°	"		extra rounds of 4.2" mortar fire
SCN			6.5	191°	"		at end of test 3A
SCN			5.6	193°	"		WPN was 105 mm Howitzer
							80% B/S observed during 30
							extra rounds of 4.2" mortar fire
							at end of Test 3A
							WPN was 105 mm Howitzer

*Data to be filled in after mission when required per test.

73-0640-VB-38

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

*GUN DATA	
Charge	
Q.E. (Mils)	
AZ (Mils)	
RADAR MODE	
Site	Eqlin Ridge
RPN	105 mm Howitzer
RPN Location (if known)	
Az (Mils)	
Ric(RM)	
Site Altitude(M)	391 m

TEST DESCRIPTION To track 30 additional rounds of 4.2"

Q.E. (Mils)		RADAR STATUS	Hi swept CFA for
AZ (Mils)		only for	20 rds, Totem Pole
RADAR MODE		10 rds (at 26 us)	
Site	Eqlin Ridge		
RPN	105 mm Howitzer		
RPN Location (if known)			
Az (Mils)			
Ric(RM)			
Site Altitude(M)	391 m		

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPT DATA RNG	B SCOPE DATA		WPN/TCT FIND	REMARKS
			RNG	AZ		
1-30	SCN		4.4 3.5	190° 195°	6 x 20 "	WPN TGT Observed 80% B/S in 4 us CFA mode. Could not see rounds in Totem Pole only mode. Good Tracks Detectability on these rounds much better than those during test 3A. Reason unknown. Note also fire point range and azimuth corresponds almost exactly with test 3A.

*Data to be filled in after mission when required per test.

73-0640-VB-39

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS		*GUN DATA		TEST DESCRIPTION		To observe radar signature of 155 mm Howitzer airburst at low Q.E. (402 mils) (Burst at 20 meter alt. Tqt = Pt 437 t. of flt ~ 23 sec.)	
Mission No.	8	Charge	4 green				
Date	1/30/73	Q.E. (Mils)	3				
Weather	Clear, Windy	AZ (Mils)					
Site	Elgin Ridge	RADAR MODE	26				
*WPN	155 mm Howitzer	Z (us)	26				
*WPN Location (if known)		STC (on/off)	ON				
Az(Mils)		N.O.B. (Deg)	+3 dB				
RNG(KM)	FP300	PPI Scale (NM)	15				
Site Altitude(M)	391	Range(M)					

Note: Radar data not reduced on computer.

MISSION DATA		PPI DATA		SCOPE DATA		WPN/TGT FIND		REMARKS	
RND NO.	FIND MODE	RNG	AZ	RNG	AZ	SCALE	WPN	TGT	
1-10	SCN	5.7	210°	6x20°		94°			Data is composite of all ten rounds. B/S varied from 100% to 20%. Burst was quite unique & lasted for 4 scans on all rounds.
		2.5	206°	"					WPN/TGT location based on longest track (1st & last point) Impact (Burst) occurred at Pt 437 ~ 2.6 NM, 204° Radar error in WPN location ~50 meters

*Data to be filled in after mission when required per test.

73-0640-VB-40

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Charge See below		Confirm 105 mm Howitzer location			
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST DESCRIPTION		TEST INFORMATION	
Q.E. (Mils)		firing 5 rds. to each of 4 impact pts.			
AZ (Mils)					
RADAR MODE					
Z (us)					
STC (on/off)					
N.O.B. (Deg)					
PPI Scale (NM)					
Range(M)					
Site Altitude(M)					
391 m					

105 mm Howitzer

*C/N DATA		TEST	

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

MISSION PARTICULARS		TEST DESCRIPTION		TEST DESCRIPTION	
Charge	See below			Three rounds to each of five impact	
Q.E (Mils)	See below	Prints	NBA424, 450, 410; SAA 307, 319	to measure	
AZ (Mils)				ability to triangulate on weapon at FP300.	
RADAR MODE					
Z (us)	26	RADAR STATUS	Hi swept CEA		
WPN	STC(on/off) on				
N.O.B. (Deg)	+3				
PPI Scale (NM)	15	MISSION REMARKS	Impact points in SAA from FP300 were		
Range(M)			almost tangential to radar and affected B/S on these		
Site Altitude(M)	391		rounds also very low charges & short range to these		

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA RNG AZ	RNG	B SCOPE DATA AZ	SCALE	WPN/TGT FIND	REMARKS
1-3	SCN		5.30	211°	6x20	WPN	75% B/S composite on 3 rds. with
CH 6, QE30	"		2.35	200°	"	TGT	best end point extremes used for
4-6	SCN		5.0	210°	"	WPN	wpn & tgt location. TGT at Pt 424
CH6, QE322	"		2.3	203°	"	TGT	80% B/S TGT at Pt 450
7-9	SCN		5.5	211°	"	WPN	See note above for Rd 1-3.
CH6, QE285	"		3.5	210.5°	"	TGT	
10-12	SCN		5.8	211°	"	WPN	60% B/S Tgt at Pt. 410
CH1, QE317	"		5.6	199°	"	TGT	See note above for Rd 1-3
							60% B/S Tgt at Pt 307
							B/S marginal due to tangential path

*Data to be filled in after mission when required per test.

73-0640-VB-42

(CONT)

PAGE 2

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

MISSION PARTICULARS		*GUN DATA		TEST DESCRIPTION	
Mission No.	_____	Charge	Q.E. (Mils)	_____	_____
Date	_____	Q.E. (Mils)	_____	_____	_____
Weather	_____	AZ (Mils)	_____	_____	_____
Site	_____	RADAR MODE	_____	RADAR STATUS	_____
WPN	_____	Z (us)	_____	_____	_____
WPN Location (if known)	_____	STC (on/off)	_____	_____	_____
Az(Mils)	_____	N.O.B. (Deg)	_____	MISSION REMARKS	_____
RNG(KM)	_____	PPI Scale (NM)	_____	_____	_____
Site Altitude(M)	_____	Range(M)	_____	_____	_____

MISSION DATA

RND NO.	FIND MODE		PPI DATA		B SCOPE DATA		WPN/TGT FIND	REMARKS
	RNG	SCN/SCH	RNG	AZ	RNG	AZ		
13-15	SCN	"	6x20°	"	6x20°	"	WPN	50% B/S data OK for cueing
CH3, QE324	"	"	See note (remarks)	"	"	"	TGT	poor for WPN loc. on all 5 series B/S data is avg. for 3rds some tracks were 100% others only 1 or 2 hits (series 5 for example) were recorded

*Data to be filled in after mission when required per test.

73-0640-VB-43

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No.	6	TEST DATA	TEST DESCRIPTION	To determine ability to CUE by identifying
Date	1/31/73	Charge	Unk	quickly approximate azimuth of unknown gun fire.
Weather	Overcast	Q.E. (Mils)	Unk	
Site	Eplin Ridge	AZ (Mils)	Unk	
FWN	105 mm Howitzer	RADAR MODE		
FWN Location (if known)		Z (us)	26	
Az(Mils)	Unk	STC(on/off)	On	
RNG(KM)		N.O.B. (Deg)	+3 db	
Site Altitude(M)	394	PPI Scale (NM)	9	
		Range(M)		

MISSION DATA

RND NO.	FIND MODE	PPI DATA	B SCOPE DATA	WPN/TGT	REMARKS
	SCN/SCH	RNG	AZ	FLND	
1	SCN			WPN	B-scope set to 2 nm, 210°. Did not see 1st round on PPI.
2-5	SCN	6.5	211°	WPN	Set B-scope for 191° 2 nm. Looked for fire on PPI.
		2.	196°	TGT	Saw rounds 2, 3, & 5 with 60% B/S.

*Data to be filled in after mission when required per test.

located on 2nd round.

73-0640-VB-44

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS	
Mission No.	9
Date	1/31/73
Weather	Overcast-lightwind
Site	Eglin Ridge
WTN	105 mm Howitzer
WTN	Location (if known)
Az(Mils)	Unk
RNG(KM)	
Site Altitude(M)	391

MISSION PARTICULARS

TEST DESCRIPTION To locate 105 mm Howitzer, fire from 6 unk pts firing to 6 unk impacts. 15 rounds to each impact pt.

RADAR STATUS Hi Swept, CFA

MISSION REMARKS Test plan called for fire from BCA to NAA/ SAA. This was changed prior to test to fire from BCA, NAA, SAA. FP for series 1, 2, 3, & 4 in or near high clutter areas.

MISSION DATA

FIND MODE SCN/SCH	PPI DATA RNG	DATA AZ	RNG	B SCOPE DATA AZ	SCALE	WPN/TGT FIND	REMARKS	
							WPN	TGT
Series 1 1-15			6.1 nm 3 nm	212° 203°	6 x 20 "			

*Data to be filled in after mission when required per test.

FP given after test was 347
11.53 KM at 3836 mils
Radar error = 850 meters

/3-DEMO-V45

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

***GUN DATA**
 Charge Unk
 Q.E. (Mils) Unk
 AZ (Mils) Unk
Weather Overcast-light
Site Eglin Ridge
***TPN** Location (if known)
 Az (Mils) Unk
 RNG (RM) Unk
Site Altitude (M) 391 m.

TEST DESCRIPTION TO LOCATE 105 mm Howitzer

<u>MISSION NO.</u>	<u>9</u>	<u>DATE</u>	<u>1/31/73</u>	<u>WEATHER</u>	<u>Overcast-light</u>	<u>RADAR MODE</u>	<u>WIND</u>	<u>RADAR STATUS</u>	<u>HIGH SWEEP CFA</u>
<u>Site</u>	<u>Eglin Ridge</u>	<u>Z (us)</u>	<u>26</u>	<u>STC (on/off)</u>	<u>On</u>	<u>N.O.B. (Deg)</u>	<u>+3db</u>	<u>MISSION REMARKS</u>	<u>FP-given after test-was FP303 (Series 2)</u>
<u>*TPN</u>	<u>105 mm H.</u>	<u>PPI Scale (NM)</u>	<u>10</u>	<u>PPI Scale (NM)</u>	<u>10</u>	<u>Range (M)</u>		<u>Again, other weapons were firing in general area. FP416 (Series 3), FP422 (Series 4), FP421 (Series 5), FP387 (Series 6) all given after test.</u>	

MISSION DATA

<u>RND NO.</u>	<u>FIND MODE</u>	<u>PPI DATA</u>	<u>B SCOPE DATA</u>			<u>WPN/TGT</u>	<u>WPN/TGT</u>	<u>REMARKS</u>
			<u>RNG</u>	<u>deg.</u>	<u>201452 NM</u>			
Series 2 16-30	SCN		5.5 2.95	211.30 199.30	6 x 20 "	WPN TGT		B/S = 80% Fire from moderate clutter area Saw all rounds
Series 3 31-45	SCN		4.5 2.95	199.0 197.0	"	WPN TGT		B/S = 80 to 90% - Looked at sever- al rds in TP only but did not see Fire from moderate clutter area.
Series 4 46-60*	SCN		4.85 2.9	2080 1970	"	WPN TGT		B/S = 70% fire from high clutter area - behind Dodge Hill saw all rds.
Series 5 61-75	SCN		4.4 2.9	1930 197.0	"	WPN TGT		B/S = 80% fire from low clutter area - saw all rds.
Series 6	SCN		3.95 3.95	184.6	"	WPN		B/S = 100% fire from low clutter area. Saw all rds.

*Data to be filled in after mission when required per test.

*NOTE: 1st reported dated FP4.7, 2080 was error in transcribing. Correct measured radar data shown above.

<u>Series</u>	<u>FP</u>	<u>FP</u>
2	710 M	303
3	250 M	416
4	760 M	387
5	290 M	422
6	200 M	421

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No.	4	Charge	Unk
Date	2/2/73	Q.F. (Mils)	Unk
Weather	Clear, Windy	AZ (Mils)	Unk
Site	Elgin Ridge	RADAR MODE	
SPWN	Unk	Z (us)	26
SPWN Location (if known)		STC (on/off) see remarks	
Az (Mils)		N.O.B. (Deg)	+3 db
RNG (KM)		PPI Scale (NM)	9
Site Altitude (M)	391	Range (M)	

TEST DESCRIPTION To fire 8 rounds ea. from 4 weapons

Q.F. (Mils)	Unk	(4.2" mortar, 105 mm Howitzer, 155 mm Howitzer & 175 mm Gun) in unk sequence from unk FP to demonstrate ability to type classify weapon
RADAR MODE		RADAR STATUS Hi swept, CFA
Z (us)	26	
STC (on/off) see remarks		
N.O.B. (Deg)	+3 db	MISSION REMARKS Weapon easily class identified after 1st
PPI Scale (NM)	9	round was fired. FP positively identified on PPI during
Range (M)		1st two rds. Weapon identified as 155 mm Howitzer.

MISSION DATA

RND NO.	FIND MODE	PPI DATA		B SCOPE DATA		WPN/TGT	WPN/TGT	REMARKS
		RNG	AZ	RNG	AZ			
Series	SCN	7.4	195°	6x200	85°			Excellent BSR on all
	"	5.65	198°	"	"			RD B/S rounds except Rd 6.
1-8								1 3/4 For Rd 6 had STC on
								2 4/4 (20 db atten at 7 NM).
								3 3/4 For all other rds STC
								4 2/4 was off.
								5 5/5 Est. of vel from B scope
								6 = .6 NM/scale = 243 m/s
								7 4/5 ground vel.
								8 Weapon classed as <u>Howitzer</u> based
								on velocity.
								After series 3 above weapon
								Classed further as 155 mm
								Howitzer based on vel. rel. to
								105 mm observed in series 3.

*Data to be filled in after mission when required per test.

Howitzer based on vel. rel. to 105 mm observed in series 3.

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

*GUN DATA		TEST DESCRIPTION See sheet 1. Mission 4	
Charge	UNK		
Q.E (Mils)			
AZ (Mils)			
RADAR MODE		RADAR STATUS	Hi swept, CFA STC set (series 2) for ~ 6 db
Z (us)	26	STC(on/off)see remarks	at 6.5 NM
STC(on/off)		N.O.B. (Deg)	+3 db
PPI Scale (NM)	9	MISSION REMARKS	Radar signature & vel. made weapon easy
Range(M)			to ID as mortar. STC was set too high for 1st 3rds
			on this low x-section tgt.

MISSION DATA

RND NO.	FIND MODE SCN/SCN	PPI DATA RNG AZ	B SCOPE DATA RNG NM	WPN/TCR FLND	REMARKS			
					AZ	200°	185°	180°
Series 2	SCN		7.35	195.5°				Rd BSR
1-8	"		6.2	200°				STC

Ground vel. computed to be 130 m/s based on spacing of hits on B-scope.

*Data to be filled in after mission when required per test.

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

<u>*CUN DATA</u>		<u>TEST DESCRIPTION</u>		<u>See sheet 2, Mission 4</u>	
Charge	Unk				
Q.E. (Mils)	—				
AZ (Mils)	—				
RADAR MODE					
Z (us)	26				
STC (on/off)	See remarks				
N.O.B. (Deg)	+3db				
PPI Scale (NM)	9				
Range(M)	—				

*WPN Location (if known)

<u>RNG(M)</u>	<u>Az(Mils)</u>	<u>Unk</u>	<u>Range(M)</u>	<u>39/m</u>

MISSION DATA

<u>RND NO.</u>	<u>PPI DATA</u>	<u>B SCOPE DATA</u>	<u>WPN/TGT FIND</u>	<u>REMARKS</u>
Series 3 1-8	SCN "	RNG AZ	SCN TGT	Rd B.S.R. STC Excellent B.S.R. with 4 3/4 On STC. Obviously larger tgt than 4.2" mortar 6 2/2 On which was impacting 7 3/3 On at same range. 8 3/3 On

Weapon was easily classed as
Howitzer on first, observed round.
Was further Id'ed as 105 mm
Howitzer based on lower vel. & cross
section relative to 155 mm Howitzer.

*Data to be filled in after mission when required per test.

73-0640-VB-49

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

		<u>*GUN DATA</u>		<u>TEST DESCRIPTION</u>		<u>See Sheet 1, Mission 4</u>	
Mission No.	4	Charge	Unk				
Date	2/2/73	Q.E. (Mils)					
Weather	Clear-Windy	AZ (Mils)					
Site	Eglin Ridge	RADAR MODE		RADAR STATUS	Hi swept, CFA, STC on		
AFN	Unk	Z (us)	26				
AFN Location (if known)		STC (on/off)	On				
Az(Mils)	Unk	N.O.B. (Deg)	+3 db	MISSION REMARKS	Weapon easily classed as gun on first		
RNG(KM)		PPI Scale (NM)	9 NM				
Site Altitude(M)	391	Range(M)			round. STC set for 10 db at 6 NM.		

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA RNG AZ	B SCOPE DATA		WPN/TGT FIND	Rd	B.S.R.	REMARKS
			RNG	AZ Deg.	SCALE			
Series 4 1-8	SCN		7.4	194	6 x 20°	WPN	1	6/6 all rds. Id'ed weapon
			2.95	196	"	TGT	2	5/7 as 175 mm gun-based
							3	Not recorded
							4	Excellent B.S.R. on vel. measured on B-scope = 1 mi. / 4 sec.
							5	7/7
							6	5/6 Rd. 3 was not recorded
							7	6/6 while vel. of weapon
							8	Not recorded
								Rd. 8 was not recorded due to taking pictures.

*Data to be filled in after mission when required per test.

73-0640-VB-50

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

MISSION PARTICULARS		*GUN DATA		TEST DESCRIPTION	
Mission No.	10	Charge 4	TOF \approx 24 sec	with masking. Wpn & tgt location known	
Date	276/73	Q.E. (Mils)	—		
Weather	Slight overcast & wind	AZ (Mils)	—		
Site FP181	West Range	Z (us)	26 us	RADAR STATUS	Hi swept, CFA
WPN	105 mm Howitzer	STC (on/off)	OFF		
*WPN Location (if known)	—	N.O.B. (Deg)	+3 dB		
Az(Mils)	FP 116	PPI Scale (NM)	10	MISSION REMARKS	Clutter in area of weapon was cancelled.
RNG(RM)	Site Altitude(M) 1310 ft.	Range(M)	—		

See computer sheets for final reduction

MISSION DATA

RND NO.	FIND MODE	PPI DATA	B SCOPE DATA	WPN/TGT	REMARKS
Series	SCN/SCH	RNG AZ	AZ	FIND	
1-25	SCN SCN	5.3 nm 2.7 nm	66.5° 60.5°	6x20° 6x20°	B/S ratio on all 25 rounds was 95%. Typically 5 hits/round were observed.
					WPN at FP116. Error in wpn location from radar data (5.3 nm at 66.5° = 9.82 km at 1180 mil) was 200 meters.

*Data to be filled in after mission when required per test.

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

MISSION PARTICULARS		TEST DESCRIPTION		To confirm 105 mm Howitzer location with masking.	
Mission No.	10				
Date	2/7/73				
Weather	Slight overcast				
Site	FP 181	RADAR MODE			
MFN	105 mm Howitzer	Z (us)	26		
Location (if known)		STC (on/off)	OFF		
Az (Mils)	FP116	N.O.B. (Deg)	+3dB		
RNG (KM)		PPI Scale (NW)	10	MISSION REMARKS	Weapon was firing over signal Mt.
Site Altitude (M)	1310 ft	Range (M)			large clutter area.

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA RNG AZ	RNG NM	B SCOPE DATA AZ	SCALE 300	WPN/RTT FIND	REMARKS
Series 2 1-25	SCN		5.2	67.3°	6x20	WPN	Excellent B.S.R. on all tracks. Some hits near impact portion of track over signal Mt. missed. Avg B/S per track was 3 to 4 hits out of 5 to 6 possible. 1st 2/3 of track ≈ 100%.
							WPN at FP116. Error in wpn location from radar data (5.2 nm, 67.3° = 9.62 Km & 1196 mils) was 270 meters

*Data to be filled in after mission when required per test.

73-0640-VB-52

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No.	11	*GUN DATA	
Date	2/7/73	Charge	UNK
Weather	Rain & Windy	Q.E.	(Mils)
Site	FP181 West Range	AZ	(Mils)
*WPN	105 mm Howitzer	RADAR MODE	UNK
	(M102 BTG on/off)	Z (us)	26 us
*WPN Location (if known)		OFF	
Az(Mils)	UNK	N.O.B. (Deg)	+3db
RNG(KM)	UNK	PPI Scale (NM)	10
Site Altitude(M)	1310 FT.	Range(M)	

TEST DESCRIPTION to locate 105 mm Howitzer from unknown

FP to unknown impact with masking.

RADAR STATUS	Hi-swept, CFA-No problems
Started test on time.	
MISSION REMARKS	Good clutter cancellation, weather
condition. Rain with high wind gust (50 knots).	

Computer data obtained on first five rounds B/S on remaining 20.

MISSION DATA

RND NO.	PPI DATA	PPI DATA	B SCOPE DATA	WPN/TGT	WPN/TGT	REMARKS
	RNG	AZ	AZ	SCALE	FIND	
Series 1-25	SCN	5 nmi	77.5°	6x20	WPN	B/S ratio on all 25 rounds was 95%. Typically 5 hits per round were observed.
		3.1 nmi	61.5°	6x20	TGT	Radar error on 1st 5 rounds 100 meters.
						Impact in area of signal ant.
						1st round observed on PPI 560 m error was noted after test was complete.

*Data to be filled in after mission when required per test.

73-0640-VB-53

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No.	11	*GUN DATA		
Date	2/7/73	Charge	UNK	
Weather	Rain and Windy	Q.E.	(Mils)	UNK
Site	FP181 West Range	AZ	(Mils)	UNK
*WPN	105 mm Howitzer	RADAR MODE		
*AFN	(ml02 ETC on/off)	Z (us)	26	us
Location (if known)	off	N.O.B. (Deg)	3	db
Az(Mils)	N	PPI Scale (NM)	10	
RNG(KM)	UNK	Range(M)		
Site Altitude(M)	1310 FE			

TEST DESCRIPTION To locate 105 mm Howitzer from UNK FP

to UNK impact with masking.

RADAR STATUS	Hi-swept CFA - no. problems. Started test
	on time.
MISSION REMARKS	Good clutter cancellation. Weather-rain with wind gusts (50 knots). Computer data obtained
	from first 5 rounds B/S ratio on the remaining 20 round.

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA			B SCOPE DATA AZ	SCALE	WPN/TGT FIND	REMARKS
		RNG	AZ	SCALE				
Series 1-25	SCN SCN	5 nmi 3.5 nm	76.5° 63.5°	6x20 6x20			WPN TGT	B/S ratio on all 25 rounds was 70% typically 3 hits per round were observed. Radar error on 1st 5 rounds 150 meters. Impact area. Signal ant. More masking was observed on series 2 than series 1 in the impact area.

*Data to be filled in after mission when required per test.

73-0640-VB-54

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

<u>*GUN DATA</u>		<u>TEST DESCRIPTION</u>		<u>TEST INFORMATION SHEET (RADAR DATA)</u>	
Charge	Unk	unk FP to unk impact (masking)			
Q.E. (Nils)	Unk				
AZ (Mils)	Unk				
RADAR MODE					
Z (us)	26	us			
STC(on/off)	off				
N.O.B. (Deg)	3	db			
PPI Scale (NM)	10				
Range(M)					
<u>Site Altitude(M)</u>	<u>1310</u>	<u>ft.</u>			

MISSION DATA

<u>RND NO.</u>	<u>FIND MODE</u>	<u>PPI DATA</u>	<u>B SCOPE DATA</u>	<u>WPN/TGT FIND</u>	<u>REMARKS</u>
1-15 Series 1	SCN	1st round 5nm	5.75 nmi 3.8 nmi	58° 6x20 6x20	WPN TGT B/S ratio on all 15 rounds 95% - typically 4 hits per round Radar error was 290 m impact area signal ant. first round error 1080 m.

*Data to be filled in after mission when required per test.

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

		<u>*GUN DATA</u>		<u>TEST DESCRIPTION</u>		<u>TEST DESCRIPTION</u>	
Charge	Unk			FP	to unk	impact	
Q.E. (Mils)	Unk						
AZ (Mils)	Unk						
RADAR MODE							
Z (us)	26	us					
STC (on/off)	off						
N.O.B. (Deg)	3	db					
PPI Scale (NM)	10						
Range (M)							

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPT DATA		B SCOPE DATA		WPN/TGT FIND	REMARKS
		RNG	AZ	RNG	AZ		
Series	SCN	4.8nm	63°	5.15 nmi	63.5°	WPN	B/S on all 15 rounds
2		(1st round)		4.1 nmi	56.5°	TGT	65% typically 3 hits observed per round.
1-15 (rounds)							Radar error 220 meters
							Impact area signal ant.
							first round error 350 m

*Data to be filled in after mission when required per test.

73-0640-VB-56

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No.	12	Charge	Unk
Date	27873	Q.E. (Mils)	Unk
Weather	Clear-Cold-Windy	AZ (Mils)	Unk
Site	FP 181 West Range	RADAR MODE	
WPN	105 Howitzer	Z (us)	26 us
WPN Location	(If known)	SRC (on/off)	off
Az (Mils)	Unk	N.O.B. (Deg)	3 deg
RNG (KM)	Unk	PPI Scale (NM)	10
Site Altitude(M)	1310 ft.	Range(M)	

TEST DESCRIPTION To locate 105 mm Howitzer from Unk

GUN DATA	FP to Unk impact
Q.E. (Mils)	Unk
AZ (Mils)	Unk
RADAR MODE	
Z (us)	26 us
SRC (on/off)	off
N.O.B. (Deg)	3 deg
PPI Scale (NM)	10
Range(M)	

MISSION DATA

RND NO.	FIND MODE	PPI DATA	RNG	B SCOPE DATA	SCALE	WPN/TGT FIND	REMARKS
	SCN/SCH	AZ		AZ			
Series 3	SCN SCN			4.75 nmi 3.8 nmi	72.7° 63.2°	6x20 6x20	WPN TGT
1-15 (Rounds)							B/S ratio on all 15 rounds 20%. Typically 3 hits were observed per round. Radar error 220 m impact area signal ant. 1st round error not obtained because of low B-S.

*Data to be filled in after mission when required per test.

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No.	15A	Seq 2
Date	2/21/73	Charge 7
Weather	Windy, Cold	Q.E. (Mils) 466618
Site	POA-2	AZ (Mils) 4900
*WPN	8" Howitzer	RADAR MODE
*WPN Location (If known)		Z (us) 26
Az (Mils)	FP24	STC (on/off) off
RNG (KM)		N.O.B. (Deg) 3db
Site Altitude (M)	1370 ft.	PPI Scale (NM) 10

*GUN DATA Seq 2
 masking. Both WPN and tgt location are known.

RND NO.	FIND MODE	PPI DATA	B SCOPE DATA	WPN/TGT FIND	REMARKS
	SCN/SCH	RNG AZ	RNG H.m	AZ	SCALE
Seq. 1	SCN		9.1	83.5°	6x20°
10 rounds	SCN		1.5	33.0°	6x20°
Seq. 2	SCN		9.1	83.5°	6x20°
15 rounds	SCN		2.5	45	6x20°

trajectory of the rounds.

MISSION DATA		PPI DATA		B SCOPE DATA		WPN/TGT FIND		REMARKS	
RND NO.	FIND MODE	RNG	AZ	RNG	AZ	WPN	TGT		
Seq. 1	SCN			9.1	83.5°	6x20°		B/S ratio for seq. 1 was 35%	
10 rounds	SCN			1.5	33.0°	6x20°		Typically 4 hits/round were observed.	
Seq. 2	SCN			9.1	83.5°	6x20°		The radar error for Seq. 1 was 225 meters.	
15 rounds	SCN			2.5	45	6x20°		B/S ratio for Seq. 2 was 25%	
								Typically 3 hits/round were observed.	
								The radar error for seq. 2 was 225 meters.	
								See computer sheets for additional info.	

*Data to be filled in after mission when required per test.

The large point clutter which captured the target for several scan would account for some of the low B/S ratios.

73-0640-VB-58

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

*GUN DATA		TEST DESCRIPTION	
Charge		from an unknown F.P. to an unknown tgt.	
Q.E.	(Mils)		
AZ	(Mils)		
RADAR MODE			
Z	(us)	26	us
STC (on/off)	off		
N.O.B. (Deg)	3		dB
PPI Scale (NM)	10		Dmi
Range(M)			
WPN Location (if known)		MISSION REMARKS	
Az(Mils)	Unk	Very heavy snow-during test-visibility	
RNG(RM)		1000 meters. Large point clutter in path of the	
Site Altitude(M)	1370	rounds.	

MISSION DATA

RND NO.	FIND MODE SCN/SCH	PPI DATA		B SCOPE DATA		WPN/TGT FIND	REMARKS
		RNG	AZ	RNG	AZ		
Seq. 1	SCN	9.8	85.0°	6x20°		WPN	The B/S ratio for this seq.
20 Rounds	SCN	2.1	29.5°	6x20°		TGT	was 20%. Typically 2 hits per round. The point clutter in the path of the round accounted for some loss of hits.

*Data to be filled in after mission when required per test.

See computer sheets for further WPN information.

73-0640-VB-59

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

<u>*GUN DATA</u>	
Charge	Unk
Q.E (Mils)	
AZ (Mils)	
<u>RADAR MODE</u>	
Z (us)	26.0 us
STC (on/off)	Off
N.O.B. (Deg)	3 db
PPI Scale (NM)	10
Range(M)	
<u>WPN</u> 8" Howitzer	
WPN Location (if known)	
Az(Mils)	Unk.
RNG(KM)	Unk.
Site Altitude(M) 1370 ft.	

TEST DESCRIPTION To locate an 8" Howitzer firing from
an unknown F.P. to an unknown target.

<u>RADAR STATUS</u>	<u>Hi swept</u>	<u>CFA</u>	<u>No failures.</u>
<u>MISSION REMARKS</u>			
Very heavy snow during the test.			
Visibility 1000 meters, large point clutter in path			
of the rounds.			

MISSION DATA

RND NO.	FIND MODE	PPI DATA		B SCOPE DATA		WPN/TGT	REMARKS
		RNG	AZ	RNG	AZ		
Seq. 2	SCN			8.8	84.5°	6x20°	WPN
	SCN			2.2	30.0°	6x20°	TGT.

*Data to be filled in after mission when required per test.

73-0640-VB-60

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

*GUN DATA		TEST DESCRIPTION		To confirm the location of a 155	
Charge 6					
Q.E. (Mils) 416.458					
AZ (Mils) 428					
RADAR MODE					
Z (us) 26					
SRC (on/off) OFF					
N.O.B. (Deg) 3 db					
Az (Mils) 10					
PPI Scale (NM) 10					
Range(M) 10					
Site Altitude(M) 1350 ft.					

RADAR STATUS No failures - rotary joint damaged when the truck hit an overhang.

MISSION REMARKS Transfer #1 was run with 0 db in the rec. front end, transfer #2 with 12 db atten. (X2 in range) Transfer #3 with 6 db atten (X 1.4 in range)

MISSION DATA

RND NO.	FIND MODE	PPI DATA	RNG	B SCOPE DATA	RNG	RNG	WPN/TGT	REMARKS
Transfer #1	SCN		6.6 nmi. 2.2 nmi	75.1° 48.7°	6x20° 6x20°		WPN Tgt.	Good blip scan (70%) was obtained for transfer #1. 5 hits out of 7 possible. Radar location error 280 meters.
Transfer #2	SCN		6.6 nmi. 2.0 nmi	74.1° 26.7°	6x20° 6x20°		WPN Tgt.	With 12 db atten. the effect range of the WPN was 13.2 nmi (24.4 Km). Blip scan good for location and cueing radar location error 360 meters
Transfer #3	SCN		6.7 nmi. 2.1 nmi.	75.6° 49.3°	6x20° 6x20°		WPN Tgt.	With 6 db atten. the effect range of the WPN was 9.3 nmi (17.2 Km) Blip scan 70% 5 hits out of 7 possible. Radar location error 80 meters.

*Data to be filled in after mission when required per test.

73-0640-VB-61

TEST INFORMATION SHEET (RADAR DATA)

Special Test
MISSION PARTICULARS
 Registration of
 Mission No. 155 Battery
 Date 2/27/73
 Weather Clear, Warm
 Site POA2
 *AFN Location (if known)
 Az (Mils)
 RNG (KM)
 Site Altitude (M) 1350 ft.

*GUN DATA
 Charge Unk
 Q, E (Mils)
 Az (Mils)
RADAR MODE
 Z (us) 26 us
 SRC (on/off) off
 N.O.B. (Deg) 3 db
 PPI Scale (NM) 10
 Range (M)

MISSION DATA

RND NO.	FIND MODE	PPI DATA		SCOPE DATA		WPN/TGT FIND	REMARKS
		RNG	AZ	RNG	AZ		
Battery Registration -	SCN	6.75 nmi	75.6°	6x20°	WPN		Good blip scan ratio 70% (5 hits out of a possible 7) radar locating error 80 meters
Rounds (5)	SCN	2.15 nmi	49.5°	6x20°	Tgt		

*Data to be filled in after mission when required per test.

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

*GUN DATA		TEST DESCRIPTION		TEST	
Charge	6				
Q.E. (Mils)	305.349				unknown fire point to an unknown target.
AZ (Mils)	331				(Battery 4 with 3 transfers)
RADAR MODE					
Z (us)	26				
STC (on/off)	off				
N.O.B. (Deg)	3deg				
PPI Scale (NM)	10				
Range(M)					
Az(Mils)					
*WPN Location (if known)					
RNG(KM)					
Site Altitude(M)	1350	ft.			

MISSION DATA

RND NO.	FIND MODE		PPI DATA		B SCOPE DATA		WPN/TGT FIND	REMARKS
	RNG	AZ	RNG	AZ	SCALE			
Transfer #1	SCN		6.15 nmi	84.5°	6x20°		WPN	Blip scan ratio 80%
	SCN		2.5 nmi	60°	6x20°		Tgt	Typically 5 hit out of a possible 6. Radar error 280 meters.
Transfer #2	SCN		6.15 nmi	85°	6x20°		WPN	Blip scan ratio 80%
	SCN		2.0 nmi	52°	6x20°		Tgt	Radar error 300 meters
Transfer #3	SCN		6.15 nmi	84.5°	6x20°		WPN	Blip scan ratio 80%
	SCN		2.0 nmi	53°	6x20°		Tgt	Radar error 280 meters

*Data to be filled in after mission when required per test.

Note: In all cases the WPN was firing approx. 600 meters from a large point clutter QRCT.

73-0640-VB-63

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No. 18
 Date 3/6/73
 Weather Clear Warm
 Site Gpte House
 *WPN 42" mortar
 *WPN Location (if known)
 Az(Mils) FP 90
 RNG(KM)
 Site Altitude (W) 1212 ft.

*GUN DATA Seq. TEST DESCRIPTION To confirm 4.2" mortar location.

Charge	1	2	Also to compare the results with the 81 mm mortar fired from the same F. P.
Q.E (Mils)	19 4/8	19 2/8	
AZ (Mils)	900		
RADAR MODE			
Z (us)	26-4		
STC (on/off)	off		
N.O.B. (Deg)	3	db	
PPI Scale (NM)	10		
Range(M)			

High point clutter in area of WPN and TGT

MISSION DATA

RND NO.	PPI DATA RNG/AZ	RNG	B SCOPE DATA AZ	SCALE	WPN/TGT FIND	REMARKS
Seq. 1 10 rounds	SCN	--	--	--	--	Seq. 1 was run in the 26 us radar mode. The high point clutter in the area of the WPN and TGT made it impossible to see the rounds.
Seq. 2 10 rounds	SCN	3.0 nmi 4.0 nmi	337° 314°	6x20° 6x20°	WPN TGT	Seq. 2 was run in the 4 us mode. The blip scan was 42%. Radar locating error 180 meters. The high point clutter in the area of the target and WPN caused some hits to be lost.

*Data to be filled in after mission when required per test.

73-0840-VB-64

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

	<u>*GUN DATA</u>	<u>seq.</u>	<u>TEST DESCRIPTION</u>	<u>To confirm 81 mm mortar location</u>
Mission No.	18			
Date	3/6/73			
Weather	Clear, Warm			
Site	Gate House			
WPN	81 mm mortar			
WPN Location (if known)				
Az(Mils)	FP 90			
RNG(KM)				
Site Altitude(M)	1212 ft.			

*GUN DATA seq. 4 TEST DESCRIPTION To confirm 81 mm mortar location

Charge	Q.E. (Mils)	1004.1020	also compare the results with the 4.2" mortar fired
Az (Mils)			from the same F.P.
RADAR MODE			
Z (us)	26-4		
STC(on/off)	OFF		
N.O.B. (Deg)	3 db		
PPI Scale (NM)	10		
Range(M)			

MISSION REMARKS Seq. 3 - 10 rounds 26 us mode

MISSION REMARKS Seq. 4 - 10 rounds 4 us mode

High point clutter in area of WPN and tgt.

MISSION DATA

<u>RND NO.</u>	<u>FIND MODE</u>	<u>PPI DATA</u>	<u>RNG</u>	<u>B SCOPE DATA</u>	<u>SCALE</u>	<u>WPN/TGT FIND</u>	<u>REMARKS</u>
Seq. 3	SCN						Seq. 3 was run in the 26 us radar mode. The high point clutter in the area of the WPN and tgt. Made it impossible to see the rounds.
10 rounds							
Seq. 4	SCN						Seq. 4 was run in the 4 us mode. The blip scan ratio was 57%. Radar location error 75 meters. The high point clutter in the area of the WPN and TGT caused some loss of hits as was the case in the 4.2" mortar. As seen from the B/S ratio the 81 mm mortar appears to be somewhat larger target.

*Data to be filled in after mission when required per test.

TEST INFORMATION SHEET (RADAR DATA)

MISSION PARTICULARS

Mission No.	17
Date	3/6/73
Weather	Clear
Site	Gate House
RFPN	175 mm
RFPN Location (if known)	
Az(Mils)	EP 30
RNG(KM)	
Site Altitude(X) ft.	1212 ft.

*CUN DATA

Charge	2
Q.E (Mils)	680
AZ (Mils)	

RADAR MODE

Z (us)	26
STC (on/off)	off
N.O.B. (Deg)	3
PPI Scale (NM)	15
Range(M)	

TEST DESCRIPTION TO confirm the location of the 175 mm

WPN	- (16 round fired)
RADAR STATUS	H. swept PRE (failure) the radar was still able to perform the mission.
MISSION REMARKS	

MISSION DATA

RND NO.	FIND MODE	PPI DATA	B SCOPE DATA	WPN/TGT	REMARKS
	SON/SCH	RNG	AZ	FIND	
Seq. 1 16 rounds	---	--	---	---	The first half of the trajectory was not seen. The last half was seen on all 16 rounds. Blip scan ratio for the entire trajectory was 31%. Blip scan ratio for the last half was 62%. Some hits were lost because of point clutter (QRCT). The rounds were seen from 12 Km to impact at 24 Km.

*Data to be filled in after mission when required per test.

73-0640-VB-66

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